Transactions
OF THE
KANSAS ACADEMY OF SCIENCE

Established 1873

VOLUME 49 - 50

(For Contents, see Index, page 461)

Published by the Kansas Academy of Science

1946-47

Manuscripts for publication or other communications concerning the *Transactions* should be addressed to the editor, Dr. Robert Taft, University of Kansas, Lawrence, Kansas.

Correspondence concerning exchange privileges should be addressed to the director of one of the following libraries:

1. University of Kansas, Lawrence, Kansas, or
2. Kansas State College, Manhattan, Kansas, or
3. Fort Hays Kansas State College, Hays, Kansas.

Volume 49 of these *Transactions* was published in four parts as follows:

Volume 49, No. 1, June, 1946, issued August 6, 1946

Volume 49, No. 2, September, 1946, issued November 12, 1946

Volume 49, No. 3, December, 1946, issued February 15, 1947

Volume 49, No. 4, March, 1947, issued April 5, 1947

Transactions
Kansas Academy of Science

Volume 49, No. 1 June, 1946

The Kansa Indians[1]

WALDO R. WEDEL
Associate Curator of Archeology, U. S. National Museum,
Washington, D. C.

It is with pleasure that we present this authoritative and comprehensive review of the original Kansans. We sometimes forget that we are but recent usurpers of the land we now possess. Present eastern Kansas, for example, was the home of a primitive people with a characteristic culture in the stormy days of Cromwell and the profligate ones of Charles the Second.

These early Kansans, possibly so called because they were either windy or troublesome (characteristics still occasionally noticeable), have been described in the study which follows by one of our leading archeologists who is himself a modern native Kansan. For further information concerning him, see page 37.—The Editor

* * *

The region lying within the present political boundaries of Kansas has been known to white men for just over four hundred years. Since that memorable summer of 1541, when Coronado led his doughty Conquistadores to its central river valleys, some twenty odd tribes have at one time or another dwelt within its borders. To some, lured thither by its teeming herds, its prairies and plains were but a transient hunting range; to others, once resident farther east, it offered temporary asylum from the westward encroachment of land-hungry whites. But to one it was both home and hunting ground for at least two hundred years of recorded history, and for an unknown period of time before. It is fitting that the name adopted for the state should perpetuate the designation borne by this one tribe whose habitat, as far back as its record can be traced, has lain entirely within the present limits of Kansas.

The Kansa Indians, by comparison with the neighboring Osage

Transactions Kansas Academy of Science, Vol. 49, No. 1, 1946.

[1]Published by permission of the Secretary of the Smithsonian Institution.

or Pawnee, were never a large or powerful tribe, nor were they an especially influential factor in frontier affairs. For a brief time in the late 18th century they stood athwart the Missouri River, blocking passage of the traders bound for the upstream tribes. For the most part, however, their history seems to have been mainly a struggle for survival—first, against their more numerous or better armed

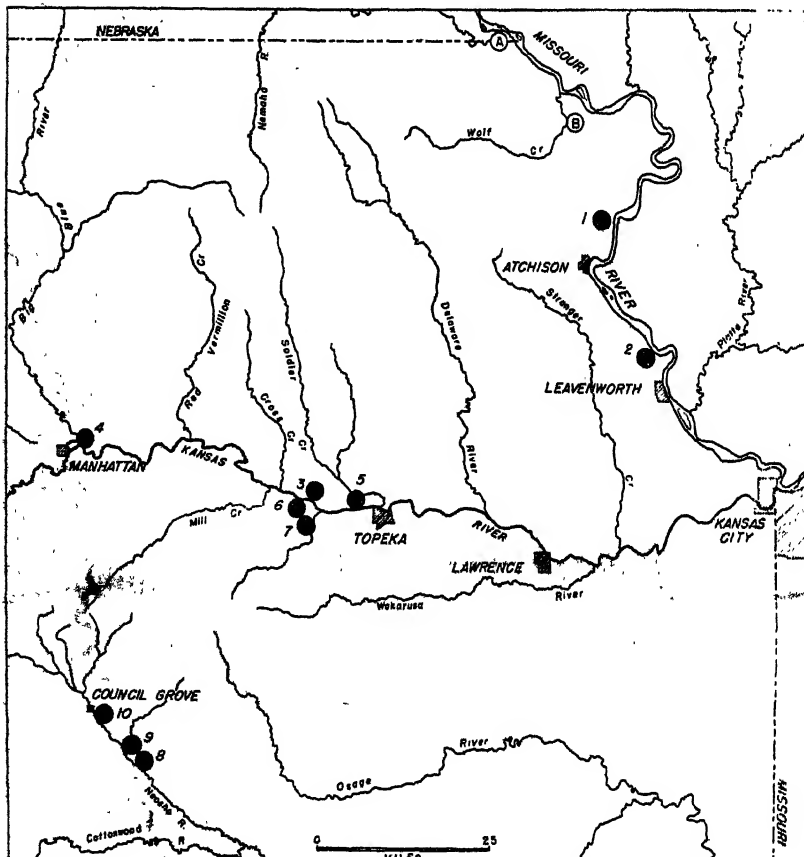


FIG. 1.—Principal known Kansa village sites in Kansas in the eighteenth and nineteenth centuries. 1, Doniphan site, the "Grand village des Quans" visited by Bourgmont in 1724; 2, Salt Creek site, with French fort and trading post in 1757; 3, the "old Kanzas village" reported by Lewis and Clark in 1804, exact location unknown; 4, Blue River site near Manhattan, occupied from ca. 1800-1830; 5, Fool Chief's village, 1830-1846; 6, Hard Chief's village, 1830-1846; 7, American Chief's village, 1830-1846; 8, Hard Chief's village, 1847-1873; 9, Fool Chief's village, 1847-1873; 10, Big John village, 1847-1873. In 1873, the remnants of the Kansa were moved to Indian Territory, residing today in eastern Kay County, Oklahoma.

The Leary site, A, and the Fanning site, B, are unidentified as to tribe; both belong to the late prehistoric and protohistoric Oneota culture of archeology, and precede in time the identified Kansa sites listed above.

Indian neighbors, and later against the rising tide of white supremacy. In this respect, their story is symbolic of the unequal struggle being waged by many of their contemporaries—tribes a little too large to be ignored or brushed aside, yet at the same time too small to maintain themselves indefinitely against pestilence, want, neglect, and injustice. It is to their credit that they were able to retain their tribal identity as long as they did—long enough, be it remembered, to see one of their own blood occupy the second highest office in our nation.

HISTORIC HABITAT

In historic times, the main villages of the Kansa were located in northeastern Kansas—first on the Missouri, then on the Kansas River, and finally on the Neosho. From this region, described by Lewis and Clark as "a delightful one, and generally well watered and covered with excellent timber," their hunting grounds lay to the west and southwest, extending somewhat indefinitely to, or a little beyond, the 99th meridian, on the Kansas and Arkansas rivers. South and southeast of their villages lay those of the Osage and, at one time, the Missouri. To the east, across the Missouri River, was a sort of no-man's-land ranged over by war and hunting parties of the Iowa, Sac, and others. Up the Missouri were the Oto and Omaha; west of these, and at one time residing as far south as the Republican River in northern Kansas, were the Pawnee. At the opening of the historic period, in the mid-sixteenth century, the great bend of the Arkansas was rather thickly peopled by the Wichita; later, this and the region westward was the bitterly disputed hunting ground of Apache, Comanche, Kiowa, Cheyenne, Arapaho, Sioux, and others.

LINGUISTIC RELATIONSHIPS; THE NAME KANSA

On the basis of the language they spoke, the Kansa are classed as Siouan, thus representing one of the most populous aboriginal linguistic families north of Mexico. Their speech affiliations, as Lewis and Clark, Pike, Say, and others early pointed out, were particularly close with the Osage, and in somewhat lesser degree with the Quapaw. Traditionally, the Kansa, Osage, Quapaw, Omaha, and Ponca once constituted a single tribe residing somewhere in the Mississippi Valley; and together they comprise the Dhegiha group of Siouan-speaking tribes. With such other Siouan-speaking peoples as the Oto, Missouri, Iowa, Dakota, etc., the kinship was more remote.

The origin and exact meaning of the tribal name are obscure.

The earliest incontrovertible mention of the tribe, in 1673, spells the name Kansa; but since that time it has been written, according to Morehouse (1908, pp. 332-336) in more than 125 different ways. The same student observes that the use of Kah-, Kaw-, or Kau- for the first syllable dates after 1800, and that previously the root of the name was consistently Kan- or Can-. Dorsey (cited in Morehouse, op. cit.) says the name " 'refers to winds,' or wind people, but that its exact meaning is not known;" and this is the interpretation, apparently correct, that has gained perhaps the most general popular acceptance. Morehouse refutes another widespread belief with the statement that there is no Kansa word for "smoky" that even remotely resembles the tribal designation; and then goes on to deny that the name is either Indian or French in origin. His own suggestion, more ingenious than convincing, is that the word was derived from the Spanish verb *cansar*, to molest, to harass, and from *cansado*, a troublesome fellow, all of which links up in turn with his acceptance of the identification of the Kansa with the turbulent Escansaques met by Onate in 1601.

ORIGIN MYTHS AND TRADITIONS

Recorded native legends purportedly explaining the origin of the Kansa are exceedingly few and fragmentary. According to Say, scientist with Major Long's expedition in 1819 (James, 1823, I, p. 125) and a visitor at the Kansa village that year, ". . .. their belief is, that the Master of life formed a man, and placed him on the earth; he was solitary and cried to the Master of life for a companion, who sent him down a woman; from the union of these two proceeded a son and daughter, who were married, and built themselves a lodge distinct from that of their parents; all the nations proceeded from them, excepting the whites, whose origin they pretend not to know. . . ."

Dorsey (1886, p. 215), in his much later account of Siouan migrations, says that the Kansa were at one time "together as one nation" with the Osage, Omaha, Ponca, and Quapaw. Collectively termed "Arkansa or Alkansa by the Illinois tribes," they then resided near the Ohio River. Here a separation took place: the Quapaw descended the Mississippi and the other tribes turned upstream to live for a time near the mouth of the Missouri. Resuming their migrations, the latter ascended the Missouri to reach finally the mouth of Osage River, where the final separation occurred. The Omaha and Ponca crossed the Missouri and continued their wanderings; the Osage ascended the river bearing their name; and the

Plate 1.—Sho-me-kos-see, the Wolf, a Kansa chief, showing the roach headdress, hair pipes, peace medal, and other native finery. No. 22 from the George Catlin collection. Courtesy U. S. National Museum.

Kansa continued up the south side of the Missouri to the Kansas River. From here, after a brief halt, they moved up the Missouri on the east [sic!] side till they reached the present northern boundary of Kansas, whence attacks by the Cheyennes compelled them to withdraw southward. They settled again at the mouth of Kansas River, where they were visited by white men and persuaded to move farther west. Subsequently, they claim to have had "about twenty villages along the Kansas River," followed by the settlement at Council Grove and finally by removal to the Indian Territory.

With reference to the Kansa, the traditions recorded by Dorsey doubtless have some basis in fact insofar as they allude to former close tribal relationships with the Osages and other groups, and to a movement from a general easterly direction into northeastern Kansas. That the route of migration actually followed or approximated that recounted here is possible but unproved. There is no extant evidence otherwise that the Kansa ever had a village at the mouth of Kansas River, or that difficulties with the Cheyenne forced them to retrace their steps from a locus at the Kansas-Nebraska boundary, or that the "Big Knives," i.e., white men, persuaded them to move from the Missouri River westward up the Kansas. There is good reason to suppose that the Kansa were firmly established on the Missouri, where the French encountered them at least as early as 1723, well before the beginning of the 18th century and probably two or three centuries before Dorsey made his inquiries. How far from the true story of migration and successive settlements the legends of 1886 were, there is at the moment no way of determining; and it is still an open question whether archeological research, our best remaining avenue of attack, will be able to amplify greatly, and correct, the traditions.

HISTORY

At what early date the Kansa first came into direct contact with white men is not certain, nor is it clear whether that first contact was with the French or the Spanish. What is generally supposed to be the earliest notice of the tribe is by Juan de Onate, governor of New Mexico from 1595 to 1607. In 1601, Onate headed a large exploring expedition northeastward from San Gabriel on the upper Rio Grande to the settlements of Quivira, apparently on the Arkansas and Walnut rivers in present southern Kansas (Bolton, 1916, pp. 257-264). Shortly before arriving at Quivira, Onate passed through a large rancheria of Indians dwelling in circular houses made of poles covered with tanned hides. Designated on the map and in other sources

Plate 2.—Chesh-oo-hong-ha, the Man of Good Sense, a young Kansa warrior. Note the roach headdress, ear adornment, shell gorget, hair-pipes, and bear-claw necklace. No. 27 from the George Catlin collection. Courtesy U. S. National Museum.

"the Escansaques" and credited with 600 houses, "... they were not a people who sowed or reaped, but they lived solely on the cattle [i.e., the bison]." They used bows and arrows, wore skin clothing, and were led by chiefs who had little authority. They lived south or southeast of the Quivirans, with whom they were at war. At first friendly to the Spaniards, they later turned against them and attacked the expedition as it was leaving the locality, but were beaten off after a spirited encounter. Their name was said to derive from the circumstance that "they extend the hand toward the sun and immediately return it to the breast saying loudly escanxaque which would signify peace...."[2]

Whatever etymological relationship the phoneticist may see between "Escansaque" and "Kansa," Onate's description of the former's mode of life sounds far more like that of some of the early plains Apache, Lipanan, or other roving hunter folk than like that of the Kansa as they are first described by the French more than a century later. It is possible, of course, that between 1601 and 1723, the Kansa shifted from a nomadic to a sedentary, semi-horticultural subsistence economy; or that, alternatively, the peoples seen by Onate were out on a seasonal hunt and had their permanent villages somewhere to the northeast. Neither of these alternatives seems very plausible; and the former would imply early "plains" affinities rather than the easterly "woodland" antecedents indicated by the linguistic and cultural relationships of the Kansa. As evidence of the location, hunting range, or cultural status of the Kansa Indians at the beginning of the seventeenth century, the notices regarding the Escansaques seem at best inconclusive.

French records of the Kansa begin apparently with Marquette, and several maps of varying accuracy and completeness (Tucker, 1942, pls. V, VI, XI A) indicate that by the last quarter of the 17th century the general location of the tribe was pretty well known. Thus, the Marquette map of 1673-74 places the Kansa, with the name spelled as in this sketch, some distance west of the 8chage (Osage), well south of the Maha (Omaha) and Otontonta (Oto), and just east of the Paniassa (Wichita). The Missouri River is omitted from this part of the map, but the relative positions of the tribal names, as just noted, suggests that these groups were in approximately the localities where the French visited or again reported

[2] "...Una rancheria de yndios que pusieron por nombre escanxaques porque ponian la mano hacia el sol y luego la bolbian al pecho diziendo a bozes escanxaques que era senal de paz...."—In Scholes and Mera, 1940, p. 274.

them early in the following century. The Randin map of 1674-81 has the "Canssa" on the south side of the Missouri River above the Missouris and below the Osage. On the Franquelin map of 1688 the Cansa are on the left bank of the Missouri, well above the Missouris. From the generalized character of all these maps, it may be concluded that, so far as the tribes of the lower Missouri valley are concerned, they were based on second- and third-hand reports rather than on careful observations. It is quite impossible to ascertain therefrom exactly where the village or villages of the Kansa stood in terms of present day geographical concepts, or to determine their number and size.

As to the ethnology of the Kansa, the maps, of course, tell us nothing. There is, however, at least one other bit of evidence that the Kansa were not unknown to native peoples residing as far to the east as the Illinois region. LaPotherie's *Histoire* (Blair, 1912, II, p. 74), believed to be based on Perrot's first hand observations during the last third of the 17th century, notes the departure from Michilimakinak of two war parties of Outaouaks (Ottawa), totaling 300 men, one of which "...was to join the Islinois against the Ozages and Kanças...." From this foray the Ottawa were dissuaded by Perrot. It would be interesting to know the background of this incident, and the circumstances that prompted a tribe from the Great Lakes region to participate in a raid against the two specified Missouri River tribes.

By 1700, or soon thereafter, it is quite probable that French traders and adventurers, pressing ever westward from the Mississippi, had visited the Kansa or met with members of the tribe, though of such encounters there seem to be no records. In 1702, d'Iberville (Hodge, 1912, pt. 1, p. 654) estimated the tribe at 1500 families. The Delisle map of 1703 (Tucker, 1942, pl. XIII) puts the "Cansa" on the north bank of a short westerly tributary of the Missouri, next above Osage River. The greatly improved 1718 Delisle map bears, apparently for the first time, the "Grande Riviere des Cansez" (Kansas River), with "les Cansez" located in an upper westerly fork of this stream; and there is another group or village of "les Cansez" on the left bank of the Missouri just below the "Petite Riv. des Cansez" (Independence Creek?), which is shown entering the main stream some distance above the Kansas River. Here, again, there is some uncertainty as to the number and exact location of the villages; but I think it safe to infer that the settlement at the mouth of the "Little

River of the Cansez" was the same village visited a few years later by Bourgmont.

As French influence spread across the plains, it came inevitably into conflict with Spanish ambitions in New Mexico. In an effort to establish friendly relations with intervening tribes who might serve as a buffer against the Spanish, Bourgmont, French military commandant on the Missouri, in 1724 proceeded from Fort Orleans, near present Malta Bend, Missouri, to the Padouca (Comanche) on the upper Kansas River (Margry, 1886, pt. VI, pp. 398-449). In early July, the party arrived at the Kansa town to spend two weeks in councils and further preparations. The village, undoubtedly the same as Renaudiere's "Grand village de Quans" is said by Renaudiere (Margry, 1886, pt. VI, p. 393) to have consisted of 150 lodges, standing near the Missouri on a small stream 30 leagues north of Kansas River. Bourgmont's chronicler, unfortunately, gives lamentably few details concerning the community. When he resumed his journey he was accompanied by two grand chiefs, fourteen war chiefs, 300 warriors, 300 women, 500 children, and at least 300 dogs to transport baggage and supplies. These figures are possibly somewhat inflated, but the company must have represented a sizeable proportion of the village population. The chiefs, or a part of them, were to escort Bourgmont to the Padouca; the rest of the assemblage was to hunt bison and then return to the village on the Missouri with a supply of meat. The reference to dogs as beasts of burden is of considerable interest as showing the method of hauling equipment on a tribal hunt in pre-horse days. Owing to Bourgmont's illness, the party turned back before reaching the Padouca; but in October of the same year, on a second attempt, he arranged a peace treaty between the Padouca and the Kansa, Osage, Missouri and neighboring tribes.

Little or nothing seems to be on record concerning the activities of the Kansa during the next three decades, but we may suppose that trade relations were assiduously cultivated with the French. Indeed, by 1757, the French had established a post among the Kansa, 80 leagues up the Missouri from the Osages and Missouris and some distance below the village visited by Bourgmont. Through this post, garrisoned from New Orleans, came about 100 bundles of furs annually. They consisted mainly of beaver, with some deer, bear, and others. Around or near the post there was a Kansa village, but whether it preceded or followed the founding of the fort is not known (Bougainville, in Margry, 1867, p. 41).

The location of the village visited by Bourgmont, and also the site of the French post and nearby village in 1757, have been identified (Remsburg, 1911 and 1919). The remains of both were noted by Lewis and Clark, Long, and other travelers on the Missouri. The village of 1724 occupied the present site of Doniphan (Wedel, 1938a), just above the mouth of Independence Creek, being probably the earliest certainly identified village site in Kansas. The 1757 village was on Salt Creek, a few miles north of Leavenworth; whether it represented a wholesale or separatist movement from the older one of 1724, or was established solely because the post had been set up on the spot, I have no evidence. That it was perhaps a short-lived community is suggested by Lewis and Clark's observation that there were no visible signs of the village in 1804, though the outlines of the French fort were plainly to be seen; at Independence creek, on the other hand, they commented on the extent of the ruins of the older village visited by Bourgmont. In any case, these two sites are the only ones on the Missouri that can be attributed with certainty to the Kansa; whether either antedates the 18th century there is no way of determining. Nor have we as yet any indication of earlier sites in the region that can be identified as Kansa.

During the middle or latter half of the 18th century the town or towns on the Missouri were abandoned, and the Kansa moved westward to Kansas River. The date of this shift is obscure, but some Spanish sources suggest it took place after 1777. In that year Cruzat (Houck, 1909, I, p. 142) included the "Cances" among the tribes receiving presents at St. Louis and observed that they ". . . are located on the banks of the Misury river itself, at a distance of some fifty leagues from the tribe of the Misuris. . . ." The distance given here is 30 leagues short of that locating the 1757 trading post, and rather suggests the Kansa may have been near the mouth of Kansas River. On the other hand, the Delisle map of 1750 and the Bellin map of 1743 both show (Paullin, 1932, pls. 23B-C) the Kansa on Kansas River; the 1757 Du Pratz map has the "Cansez G^{d}. Village" on the Missouri and the "Cansez" on the "R. des Cansez."[3]

All of this suggests some confusion and uncertainty in sources of information, or else that there may have been a somewhat drawn-out drift toward the southwest which saw the founding of a settlement or hunting camps on Kansas River even while the traders trafficked through the Missouri River villages. In any case, the

[3]See Morehouse, 1908, fn. p. 344, and Strong, 1935, p. 12 for additional summarized map data on the Kansa.

movement was completed sometime before 1798, for in that year Trudeau reported (Houck, 1909, II, 252) that "... the Kance tribe has its village located on the banks of the river of that name...." and the 1796 Collot map has the "N. Can", i.e., nation of the Kansa, at the mouth of the Blue Water, i.e., Blue River.

There is no direct or contemporary explanation for the movement away from the Missouri. It seems remotely possible that in so doing, the Kansa were returning to an older habitat, to a region occupied perhaps before the identified sites on the Missouri. Lewis and Clark, as they passed the site above Independence Creek, conjectured that the Kansa there had been driven away by more powerful or better armed enemies, and had sought security on the plains where they could maneuver with their horses (Thwaites, 1904, I, p. 67). Possibly the lure of better bison-hunting and greater success in beaver-trapping were partially responsible. That the Dakota or the Cheyenne were instrumental in driving the Kansa out of northeastern Kansas on to the river bearing their name, as tradition relates, seems improbable. On the other hand, increasing pressure from the Iowa, Sac, Fox, and other easterly tribes may well have played a part. Whatever the cause or causes, once the sites along the Missouri were abandoned, the tribe apparently never returned, as a village unit, to the valley.

At what point on Kansas River the Kansa first settled after their withdrawal from the Missouri is not certain. Lewis and Clark (Thwaites, 1904, I, p. 60) credited the Kansa with two villages in 1804, "... one about 20 leagues and the other 40 leagues...." up the Kansas. Elsewhere (Thwaites, 1904, VI, p. 36), however, in a summary table of various features of the Kansas River system, they note "The old Kanzas Village" on the north bank 9 miles above "Heart river" (Soldier creek) and 40 miles from the Missouri; and "Bluewater river and the present village of the Kanzas just below" are said to be 80 miles up the Kansas. This latter reference, clearly, is to the village near the mouth of Blue River, just east of present Manhattan, and the implication is that there was but this one occupied village. The old village evidently lay between Soldier creek and the Red Vermillion, perhaps somewhere in the vicinity of present Silver Lake; so far as I am aware, its exact location has never been determined.

Of the villages sometimes attributed to the Kansa above Blue River I have found no conclusive proof. McGee's assertion (1897,

p. 193) that in 1803 they dwelt in 30 lodges at the mouth of the Saline River apparently stands by itself (Cf. Morse, 1822, p. 237). In 1811, Maj. Sibley visited a village of 128 lodges on the north bank of Kansas River, "about one hundred miles by its course above the junction with the Missouri" and a few hundred paces below the Republican fork (Sibley, 1922). The Republican falls into the Kansas considerably more than 100 miles above the Missouri, suggesting that Sibley may have mistaken the Blue for the Republican; or, if the location is correctly given, this may have been a hunting camp, though the further description implies something more permanent. The principal Kansa village, and apparently the only one of permanence, from ca. 1800 to 1829 or thereabouts seems to have been that below the mouth of the Blue. The site, now occupied by an evergreen nursery and farmlands, and traversed by the Union Pacific railroad, has been greatly reduced in area by lateral erosion of the Kansas River. Standing on a sightly terrace about 2 miles east of present Manhattan, the town had in the neighborhood of 120-200 lodges during its heyday. From here, according to Pike, who bypassed the town en route to the Pawnee, came annually 250 bundles of deerskin, 15 of beaver, and 100 of otter, traded at St. Louis for $8,000 worth of merchandise (Pike, 1910, appendix to pt. II, p. 53). It was here too that Prof. Say, of Maj. Long's expedition, visited the tribe in 1819 and collected the ethnographic data that still comprise our fullest account of the customs of the Kansa in their original state (James, 1923, I, pp. 120-130; see also the *Analectic Magazine,* new series, vol. 1, nos. 4 and 5, April and May, 1820, Philadelphia.)

For the Kansa, as for other tribes of the region, acquisition by the United States of the vast territory comprising the Louisiana Purchase had far-reaching consequences. Closely linked with development of the sparsely populated new lands was a plan for removal from the relatively heavily settled eastern United States of the tribes still resident there, and their settlement in the trans-Mississippi region. Before such wholesale removal could be undertaken, it was necessary to extinguish the primary title of the indigenous tribes (Abel, 1904). To the achievement of this initial objective, the Kansa were among the first victims; and an immediate result was the establishment of the first reservations in the state. On June 3, 1825, the Kansa and Osage signed a treaty at St. Louis, drafted by Gov. William Clark, of Lewis and Clark fame. By this treaty, the Kansa relinquished their claim to the greater part of their holdings in eastern Kansas, and were assigned a tract beginning 20 leagues

up Kansas River and extending indefinitely westward with a uniform width of 30 miles. Soon thereafter began a movement down river, and by 1830 the village at the mouth of Blue River had been abandoned for three others some 35 miles to the east.

The new villages, inhabited from 1830 to 1846, were situated a few miles above present Topeka (Morehouse, 1908, p. 346; Adams, 1904). The largest, under Fool Chief, stood on the north bank of Kansas River about 6 miles above Soldier creek and just north of present Menoken (pl. 3a). Here, or at one of the neighboring villages, Catlin claims to have visited in 1831; and in that or the follow-

Plate 3a.—Fool Chief's village, near present Menoken, Kansas, in 1841. Drawn by George Lehmen, probably after a sketch by Father Nicholas Point, artist; from De Smet's Letters and Sketches. Courtesy Bureau of American Ethnology.

ing year, he painted several of the tribe's notables (see, for example, pls. 1 and 2). Here, too, Father De Smet, on his missionary tour of the Indians, visited in May, 1841 (Thwaites, 1906). He estimated i's population at 700 or 800, and briefly described its appearance and inhabitants. Two miles south of the river, on the west side of Mission Creek, was American Chief's village of 20 lodges. Two miles away, on high land nearer the river and about 1½ miles west of Mission Creek, was Hard Chief's village of 100 lodges. Below Fool Chief's village, and fronting on the north side of the river, were allotments for

23 half-breeds, mostly with French blood. At the lower end of this strip, near present Williamstown, was established the first agency for the tribe, with a blacksmith and farmer attached. Here, also, under the Methodist auspices was opened the first mission to the Kansa, in charge of William Johnson. In 1835, a new mission was erected at American Chief's village, where it operated until Johnson's death in 1842.

At this mission, on January 14, 1846, the Kansa entered into another treaty with the Government whereby they ceded the eastern end of their tract, 30 miles square, with the stipulation that if the remainder was insufficiently timbered for their needs, they would be given lands elsewhere. The latter proving to be the case, the Kansas River lands were exchanged for a reservation south of the river, on the Neosho around historic Council Grove.

On this new reservation, where the Kansa dwelt from 1847 to 1873, three new villages sprang up (Morehouse, 1908, p. 353). Hard Chief's village, now largest of the three, was on Cahola Creek south of present Dunlap. Fool Chief's village was in the Neosho valley near the same present town. The third village was to the northwest, near Big John Creek southeast of Council Grove, and not far from the agency. Here further educational and missionary efforts were undertaken, but not generally with marked success.

Proximity to Council Grove, a prominent station on the Santa Fe trail, and contact with unscrupulous traders, whiskey peddlers, and other frontier riffraff, far more than offset the perfunctory efforts of government and church at social uplift. The reports of the Indian agents, particularly that for 1855, vividly portray the decay of the tribe. After the treaty of 1859, which further reduced the reservation, much new construction took place in connection with the agency, including the erection of some 150 small stone cabins for individual Indian families. These, for the most part, went unused, the Indians preferring the lodges and tipis to which they and their forebears had so long been accustomed. Scant success, too, attended the efforts of the government, either at Mission Creek or on the Neosho, to make farmers of the tribe; so long as the bison herds remained, there seem to have been annual hunts, organized on a tribal basis, and involving a large proportion of the able bodied members of the tribe.

During the twenty-five years residence on the Neosho, the tribe underwent probably the most marked decline, numerically and otherwise, in its recorded history. With exception of d'Iberville's esti-

mate of 1500 families in 1702, and the 1764 estimates of Hutchins and Bouquet of 1600 fighting men, the figures for the Kansa suggest a fairly stable population of between 1300 and 1700 from at least 1723 until about 1850. If, in place of "families" and "fighting men" we read "persons," the figures by d'Iberville, Hutchins, and Bouquet fall nicely into line. As late as 1836, while still on Kansas River, their numbers were put by the War Department at 1606; Gregg gives it as 1700 in 1844. Yet, a census in 1869, four years before the removal from Kansas, sets the figure at 525. Part of this decrease can be laid to the devastating smallpox epidemic of 1855, when more than 400 Kansa perished. In even greater measure, the responsibility for the marked decrease in the late '50's and '60's lay in the short-sighted policy that exposed the tribe, without educational preparation or other adequate safeguards, to the vices, diseases, and general demoralizing influences of a frontier trading center. This chapter in the story, clearly traceable in the successive reports of the Indian agent to the Kansa, is none the less tragic in that it was repeated again and again in countless other instances by the same government.

In 1873, just 200 years after their first recorded notice, the remnants of the Kansa, their lands overrun by white settlers, left the reservation on the Neosho for another adjoining the Osage lands in the Indian Territory. Here somewhat more progress was made in persuading them to farm and grow livestock. Their numbers, how-

TABLE 1.—Estimates of Population for the Kansa Indians since 1723.

Year	*Authority*	*Villages*	*Lodges*	*Warriors*	*Population*	*Reference*
1723	Renaudiere	1	150			Margry, 1886
1724	Bourgmont	1		500		Margry, 1886
1757	Du Pratz	2(?)			"Pretty considerable"	Du Pratz, 1774
1764	Hutchins			1600		Schoolcraft, 1853
1764	Bouquet			1600		Schoolcraft, 1853
1777	Cruzat	1		350		Houck, 1909
1798	Trudeau	1		400		Houck, 1909
1803		1	30		1500	McGee, 1897
1804	Lewis and Clark	1		300	1300	Thwaites, 1904
1806	Pike	1	204	465	1565	Pike, 1810
1811	Sibley	1	128			Sibley, 1922
1819	Long	1	130		1500	James, 1823
1820	Sibley O'Fallon			230	800 1750	Morse, 1822
1829	Porter				1200	Schoolcraft, 1853
1830		3	140		1300-1500	Morehouse, 1908
1830	Chouteau	3			1300-1500	Adams, 1904
1832	Catlin				1560	Catlin, 1841
1834	War Dept.				1440	Schoolcraft, 1853
1835					1471	Comm. Ind. Aff., 1835
1836	War Dept.				1606	Schoolcraft, 1853
1844	Comm. Ind. Aff.				1700	Gregg, 1844
1851					1600	Schoolcraft, 1851
1855					1375	Comm. Ind. Aff., 1855
1860					803	Comm. Ind. Aff., 1860
1869					525	Comm. Ind. Aff., 1869
1880					300+	Comm. Ind. Aff., 1880
1900					217	Comm. Ind. Aff., 1900

ever, continued to dwindle. By 1900 there were but 97 full-bloods and 127 mixed bloods. Their lands in the Territory have been divided and allotted in severalty, and today, what remains of the Kansa tribe resides in a small tract near the Arkansas River in eastern Kay County, Oklahoma.

PHYSICAL, MENTAL AND MORAL CHARACTERISTICS

Concerning these aspects of the Kansa, we have only a few cursory observations dating from the days before tribal integrity fell into decay. According to Say (James, 1823, I, p. 126), the Kansa were intermarrying freely with the Osages in 1819, "... so that in stature, features, and customs they are more and more closely approaching that people. They are large and symmetrically well formed,[4] with the usual high cheek bones, the nose more or less aquiline, color reddish coppery, the hair black and straight. Their women are small and homely, with broad faces. We saw but a single squaw in the village who had any pretensions to beauty...."

Father De Smet, in 1841, similarly comments (in Thwaites, 1906, p. 201) that "In stature, they are generally tall and well made. Their physiognomy is manly...."

Say observes further that "They bear sickness and pain with great fortitude, seldom uttering a complaint; bystanders sympathize with them, and try every means to relieve them. Insanity is unknown; the blind are taken care of by their friends and the nation generally and are well dressed and fed. Drunkenness is rare, and is much ridiculed; a drunken man is said to be bereft of his reason, and is avoided...."

To this we may add a further note by De Smet (ibid., p. 205): "However cruel they may be to their foes, the Kanzas are no strangers to the tenderest sentiments of piety, friendship, and compassion. They are often inconsolable for the death of relations, and leave nothing undone to give proof of their sorrow...."

And again De Smet (ibid., p. 201): "With regard to the qualities which distinguish man from the brute, they are far from being deficient. To bodily strength and courage they unite a shrewdness and address superior to other savages, and in their wars and on the chase they make dexterous use of firearms, which gives them a decided advantage over their enemies."

---

[4]In apparent confirmation of this observation, it may be noted that among the early historic Kansa burials excavated near Doniphan by the U.S. National Museum in 1937 (Wedel, 1938a), were several large robust male skeletons. These suggest a noticeably taller, heavier-boned, and more rugged physical type than is indicated archeologically for the known prehistoric peoples of the region. Head deformation is not indicated archeologically nor ethnologically.

MATERIAL CULTURE

The subsistence economy of the Kansa, like that of the Osage, Pawnee, and other village tribes of the eastern plains border, was based partly on hunting and partly on horticulture (Wedel, 1941). Concerning the latter there is relatively little detailed information, and some sources (Cruzat, in Houck, 1909, I, p. 142, and Sibley, in Morse, 1822, p. 205) leave the impression that it was of secondary importance. It is a matter of record, however, that maize, beans, pumpkins, watermelons, and muskmelons were grown, the women doing all the work of cultivation, harvesting, and storing of the crops. The principal agricultural tool was the hoe, made in the old days by lashing a shoulder blade of the bison to a stick; later, iron hoes were introduced by white traders. Corn was used in various ways; Say (James, 1823, I, p. 122) speaks of "leyed corn," i.e., hominy; of fresh corn made into a soup with a few slices of bison meat and beans added; and of roasted corn on the cob. It was also pounded up, but whether in a stone or wooden mortar is not clear. Muskmelons and watermelons were harvested before they had ripened. Maize and beans intended for future use were dried, packed in skins or mats, and stored in underground caches. Of sunflowers, squash, and other domesticated species known to neighboring tribes there is no specific mention for the Kansa, and the literature is generally silent as regards the use of wild fruits, berries, nuts, roots, and seeds. It is a safe assumption, however, that non-domesticates were utilized when needed or available.

The timber-lined watercourses of the Kansa country abounded in a great variety of game. To the deer, bear, elk, beaver, turkey, and smaller forms available close at hand, the Kansa added the more distant bison. In historic times, as doubtless long before, their hunting grounds lay on the upper reaches of the Kansas River and on the Arkansas. I suspect that the Kansas River derived its name from this circumstance rather than from a possible permanent residence on the stream before they settled on the banks of the Missouri. During the historic period, annual hunts involving most of the able-bodied populace were staged regularly; and these were probably an elaboration of a practice pursued before horses were available. According to Lewis and Clark (Thwaites, 1904, VI, p. 85), the Kansa were "... stationary at their villages, from about the 15th of March to the 15th of May, and again from the 15th of August to the 15th of October; the balance of the year is appropriated to hunting. ..."

The annual tribal hunts were continued as long as the bison were

available in sufficient numbers to make the effort worthwhile.[5] Even after removal to the reservation on the Neosho, hunting parties were dispatched to the western country. Eventually, this resulted in a well-defined trail, beginning near the mouth of Big John Creek southeast of Council Grove. Thence this trace, known as the Kaw Trail (Morehouse, 1904, p. 206) ran slightly south of west to cross Diamond Creek within a few yards of the Diamond Springs railway station. It entered Marion County near the old Bethel post office on the head of Middle Creek, not far from present Lincolnville, thence ran westward through Marion and McPherson counties to the forks of Cow Creek, a few miles south of present Lyons. The route generally paralleled the Santa Fe trail, at a distance of 3 to 6 miles to the south. From the camp on Cow Creek, some of the Indians returned with meat to the villages in late fall; others, attracted by better forage for the horses, spent the winter on the spot.

We may suppose that success in the bison hunt entailed a period of heavy feasting. Surplus meat was preserved by drying; Say's party, before leaving the Kansa village on Aug. 23, 1819, purchased jerked bison meat and "bison fat put up like sausages." The preparation and preservation of the meat, as also the dressing of the hides, was the work of the women.

For seasoning their meat and vegetable dishes, the Kansa used rock salt obtained, according to Say, near the Arkansas River.

Of domestic animals only the dog was known to the Kansa before the 18th century. It functioned principally, in conjunction with the travois, as a draft animal, with secondary uses as a food delicacy, a pet, or for sentry purposes. Three hundred of the animals accompanied the Kansa when they left their village with Bourgmont on his first attempt to reach the Padouca in 1724; and he observes (Margry, 1886, VI, p. 414) that "... Un seul chien traisne les peaux pour faire une cabane pour loger dix a douze personnes avec leurs plat, chandieres et outre utensiles, qui pesent environ trois cents livres...."[6] This estimate of individual performance seems high, but the account strikingly underlines the economic importance of dogs at the time. Horses had evidently been introduced not long before, so that Bourgmont encountered considerable trouble in purchasing animals for his needs. The Padouca, by trade with and raids against the Spanish settlements on the Rio Grande, were better sup-

[5] Skinner (1915, p. 746) describes the organization of leaders and police for regulating the tribal hunt.

[6] "A single dog drags the skins for making a 'cabane' to house 10 or 12 people with their dishes, kettles and other utensils, which weigh about 300 pounds."

plied, and it was perhaps through trade with them that the Kansa as also other nearby Missouri valley tribes first acquired the animals. Once introduced, their advantages were so apparent that they were kept in large numbers. Thus, at the village on Kansas River in 1811, Sibley (1922) observed that: "The prairie was covered with their horses and mules (they have no other domestic animals except dogs)." The significance of the horse, in terms of greater mobility and freedom in the food quest and warfare, and in moving camp and personnel from one location to another, need not be discussed in detail here.

Plate 3b.—Kansa bark-covered lodge; locality unspecified, date probably 1880-82. Courtesy Bureau of American Ethnology.

At least two, and probably three, types of habitation were used by the Kansa. Regrettably, the 18th century accounts by French observers contain no descriptions of the permanent dwellings. Bourgmont (Margry, 1886, *passim*) refers repeatedly to the "cabanes" and the "cabanage" of the Kansa grand village, but we can only speculate as to whether they were of bark, of earth, or of some other material. That the portable skin-covered tipi was customary when the tribe was on the move can be inferred from Bourgmont's observation, quoted above, concerning the draught abilities of the dogs.

This form of structure, of course, continued to be an indispensable part of the hunting paraphernalia of the people throughout the later historic period.

The first detailed description of permanent Kansa habitations, so far as I have been able to learn, is Sibley's account of 1811. Neither Lewis and Clark in 1804, nor Pike in 1806, visited the tribe's occupied towns, and we have only Pike's general but imprecise statement (Pike, 1810, opp. to pt. II, p. 17) that the Kansa were "in language, manners, customs, and agricultural pursuits, precisely similar to the Osage," who dwelt in bark- and mat-covered houses. In any case, Sibley wrote that the Kansa town contained 128 lodges, "... which are generally about 60 feet long and 25 feet wide, constructed of stout poles and saplings arranged in form of an arbour and covered with skins, bark and mats; they are commodious and quite comfortable. The place for fire is simply a hole in the earth, under the ridge pole of the roof, where an opening is left for the smoke to pass off. All the larger lodges have two, sometimes three, fireplaces; one for each family dwelling in it. The town is built without much regard to order; there are no regular streets or avenues. The lodges are erected pretty compactly together in crooked rows, allowing barely space sufficient to admit a man to pass between them. The avenues between these crooked rows are kept in tolerably decent order and the village is on the whole rather neat and cleanly than otherwise. . . ."

Of quite different appearance and construction were the earth-covered lodges in which the Kansa were dwelling just below Blue River when visited by members of Long's party in 1819. Of these we have an excellent description by Say (James, 1823, I, p. 120). They were circular in plan, with the floor excavated one to three feet below the adjoining surface. The chief's house, in which Say resided, differing from the others only in its greater size, had twelve posts set just within the excavated area, and eight longer ones forming an inner circle. In smaller houses four center posts were sufficient. Beams ran from post to post around each of these circles, and other poles, their butts resting on the outer series of beams, ran inward and upward to meet very nearly at the summit. Across these were placed slender rods, laid parallel to each other and lashed with bark, and these were covered with matted grass, reeds, or bark slabs. A steeply sloping wall was built in similar fashion, and the whole structure was banked and covered with earth. A covered tunnel-like passageway to the east formed the doorway. The fireplace was an un-

lined circular basin in the center, whence the smoke found its way out through the hole left at the summit. Against the wall, between the outer circle of posts, were raised bunks, padded with bison robes and screened with mats. To some of these mats were attached medicine bundles, ornamented with scalps. Beside the fireplace was an upright pole with an inclined arm to support a cooking pot over the hearth.

These hemispheric structures, used by many other tribes of the Missouri valley, were in large compact villages laid out without much regularity, and unfortified. They varied in diameter up to 30 or 40 feet and could accommodate 30 or more persons. Their saucer-shaped ruins were visible on the Kansa village sites for years before the land was plowed, and the general floor plans can still be confirmed by the archeologist (pl. 4, upper).

Bark and mat habitations, such as Sibley described, were a widespread woodland form common to many eastern tribes; the circular earthlodges seen by Say were equally typical of the farming tribes of the eastern plains. In using both, the Kansa, originally an eastern tribe, seem to have been holding onto an old and familiar concept in the bark house on the one hand, while at the same time experimenting with a new tradition, the earthlodge. It would be interesting to know whether the house ruins seen by Lewis and Clark at the Kansa towns on the Missouri were those of bark lodges or of earthen structures. Also, it would be interesting to know whether both types continued in use after Say's time. A traveler at the Mission Creek villages in 1834 speaks of bark and skin houses but makes no mention of earthlodges (Townsend, cited in Bushnell, 1922, p. 94); and the drawing left by one of De Smet's companions in 1841 (see pl. 3a) shows the lodges with vertical walls and overhanging eaves such as no plains earthlodge would have (see also Thwaite's, 1906, p. 198). Spencer (1908, p. 373) leaves the impression that skin tipis were the rule in the Neosho valley villages.

In the matter of dress, according to Say (James, 1823, I, p. 126-129), the men wore a blue or red breech cloth secured by a girdle, deerskin leggins, moccasins with no ornamentation, and sometimes a blanket over the upper part of the body. Shells, beads, or metal ornaments were attached to the rim of the ear, sometimes in great profusion, and long slender hair pipes were often worn. The head was shaven, leaving only the scalplock uncut. Sometimes the edge of this lock was colored with vermillion, or an eagle feather was inserted. More striking was attachment to it, on top of the head, of

Plate 4.—Upper, Cleared floor of Kansa earthlodge, at site east of Manhattan, showing central fireplace, postholes, shallow storage basin, and vestibule entrance. Kansas River at extreme upper right.

Lower, Stone-covered burial, probably Kansa, at the Doniphan site.

the tail of a deer, dyed red, and parted longitudinally by a silver plate. Face hair was plucked by means of a spiral wire, placed sidewise over the part and the ends pressed together. Formerly, says Catlin (1841, II, p. 23) red hot stones were employed for the purpose. In warm weather the men carried turkey feather fans to cool themselves and shield the head from the sun. De Smet (Thwaites, 1906, p. 200) gives a brief description of Kansa Indians dressed for special occasions in their finery of paint, copper or silver breast pieces, bracelets, etc. (cf. pls. 1 and 2).

Women wore moccasins, knee-length leggins of blue or red cloth, a short skirt, and occasionally a cloth thrown over one shoulder. Their hair was worn long, parted on the midline, and the part colored with vermillion. Like the men, many of the women tattooed the body.[7]

Household furniture and utensils were simple and utilitarian. Brass kettles, iron pots, and wooden bowls and spoons are mentioned by Say, but significantly, he says nothing of native earthenware.[8] Bison-horn spoons were also used. Each person, male and female, carried a large knife in the girdle, for use at meal times which came four or five times a day, or for self-defense. Bedding consisted of bison robes. The screens used to give privacy in the sleeping alcoves, according to Say (James, 1823, I, p. 121) were mats "...of neat workmanship, composed of a soft reed, united by bark cord, in straight or undulated lines, between which, lines of black paint sometimes occur...."

Firearms were in use among the Kansa by Bourgmont's time, but it may be assured that they remained scarce for a long time thereafter. In 1806 Pike (1810, app. to pt. II, p. 53) credits the tribe with 450 guns. Their bows, of which a good description is lacking, were made of Osage orange, procured along the Arkansas River, or of ash, elm, or iron-wood; and for arrows the straight knot-free sapling of dogwood was preferred (La Flesche, 1924, pp. 112-113). Say and De Smet record, without description, the lance among the Kansa; the finding of stone war-club heads at the Doniphan site establishes the use of this item. Of shields (De Smet, in Thwaites,

---

[7]According to Skinner (1915, p. 753), tattooing on the breast was the greatest honor that could be accorded a warrior, indicating the slaying of seven foemen or the capture of six horses. A very successful warrior could have his wife tattooed. The tattooing was done by certain men who owned tattooing bundles.

[8]That the Kansa had indeed ceased the manufacture of pottery by the time they settled at the mouth of Blue River is demonstrated also by archeological findings here. By Say's time, the tribe had been in contact with French traders for a hundred years or more, and the Blue River site is littered with fragments of steel traps, metal kettles, guns, etc., but no potsherds. Unless it be at one of their early 18th century sites on the Missouri, the nature of their ceramic tradition, an important point in tracing the tribe's cultural origins, may never be conclusively established.

1906, p. 197) and other defensive devices, I have found no description.

Pipes of Minnesota catlinite, purchased from northern tribes, were highly prized, but Spencer (1908, p. 380) says these were not necessarily the "pipe of peace."

In 1834 Townsend (cited in Bushnell, 1922, p. 94) found the Kansa, evidently in the Mission Creek locality, using canoes "mostly made of buffalo skins, stretched, while recent, over a light frame work of wood, the seams sewed with sinews, and so closely, as to be wholly impervious to water. These light vessels are remarkably buoyant, and capable of sustaining very heavy burthens."

SOCIAL USAGES AND POLITICAL ORGANIZATION

For information on the social and political customs of the Kansa under the native way of life, we again fall back on the observations of Say in 1819. Elsewhere, there are scattered bits of data by other travelers, and finally from late reservation days there are the ethnographic findings of Dorsey and Skinner.

According to Say, the newborn infant was washed repeatedly in cold water, and the mother also bathed soon after the delivery. The infant, tightly swathed, was lashed to a cradle board. Children were much desired, but were poorly disciplined and generally disobedient, especially the males. Far from causing displeasure to the parents, this was regarded as a favorable omen for the future greatness and independence of the boys as warriors and leaders when they reached manhood. According to Say, young men were generally "coupled out as friends," and this Damon and Pythias relationship was often life long.

The chastity of the young women was scrupulously guarded by the mothers, since its violation would unfit the individual to be the wife of a chief or successful hunter and warrior. Say noted, however, the presence of "several courtezans" in the village.

When a young man decided to marry, he either went direct to the girl's father or else proceeded through an intermediary. The marriage ceremony (James, 1823, I, p. 123) involved an exchange of wedding presents, consisting of horses, meat, blankets, and miscellaneous merchandise, and a feast by the bride's parents. The groom moved to the lodge of his bride's parents and there established residence. The eldest daughter married first, and assumed command of the lodge, including her mother and sisters; the latter became the wives of the same man, unless he chose otherwise. In the interests

of harmony, only women who were sisters became the wives of the same man.

The division of labor between the sexes, judged by our standards, was decidedly one-sided. The women did all the work of cultivation, harvested and processed the food crops, carried wood and water, attended to the culinary and other household duties, cured the meat, dressed the hides (see Spencer, 1908, p. 379), set up the tipis, and fashioned the garments. To the men fell the responsibilities of warfare, hunting and trapping, beyond which their time seems to have been devoted mainly to gambling and loafing.

On the death of the husband the widow scarified herself, covered her person with clay, fasted, and became negligent of her dress and personal appearance for a year. Thereafter, the eldest brother of the deceased took her to wife without ceremony, accepting her and her children into his house as his own. If there was no brother, the widow was at liberty to marry whom she pleased. When the wife died, the husband daubed his face with clay and wandered about wailing. For eighteen months, according to Dorsey, he fasted daily from sunrise to sunset; after sunset he washed and partook of food. At the end of the period of mourning, the husband gave presents to the wife's brothers; if the wife survived, she gave presents to the sister and younger brother of her former husband. Failure to observe these customs might lead to violence toward the survivor on the part of the decedent's kin.

In the old days, when a warrior died (Dorsey, 1885; cf. Adams, 1904, p. 429), a pipe was given to an important man in the tribe, who thereupon underwent a 6-day fast. Following this he summoned, from among the blood or marriage relatives of the deceased, a group to form a war party. The "war-captain" daubed his face with clay, fasted, and performed the "ceremonies of the ancients." Next day, in a specially erected tent, he led the mourning ceremonies, for which he was rewarded with gifts of horses and merchandise. The prospective members of the war-party next met in a special lodge for further rituals. These included smoking the sacred pipe, a flat disk-bowled affair of red pipestone, and rites over the sacred clamshell. The shell was held in the left hand, and smoke was blown into it, whence it ascended to the thunder-god, the god of war. This was followed by much singing by the assembled warriors, who followed a bison skin chart covered with pictographs. Then came another round of smoking, after which the men slept briefly. At daybreak they departed on the warpath. In pre-reservation days, it was neces-

sary to bring back the scalps of one or more Indians; later, the slaying of prairie chickens sufficed, for, according to Dorsey, "Thus was life taken, and the mourners were satisfied." The warriors then washed their faces, ate, and returned home.

Burial was in individual dug graves, on the top of some hill or bluff near the village, and the graves were commonly covered with limestone slabs (pl. 4 lower). Where, as at the Blue River village, the limestone bluffs were some distance away, the graves were made on the river terrace at a little distance from the village. Bodies were extended or in a semi-reclining posture, less often flexed. There were, to judge from archeology, few accompanying objects (compare Skinner, 1915, p. 772). Morehouse (1904, p. 208) says that a pony was killed on the grave in later reservation days. According to Say "... Thinking the deceased has far to travel they bury with his body, mockasins, some articles of food, etc., to support him on the journey...."

Concepts of a life after death seem to have been rather vague. According to Say (James, 1823, I. p. 125) "They think that a brave warrior, or good hunter will walk in a good path; but a bad man or coward will find a bad path...."

Dorsey (1894, p. 422) reports a belief among the Kansa that on death, the ghost returns to a spirit village, which was at the site of the last village occupied prior to establishment of the contemporary town. Thus, there is a succession of ghost villages retracing the wanderings of the tribe through Kansas, down the Missouri River, back to Ohio, and beyond.

The Kansa tribal circle consisted (Dorsey, 1897, pp. 230-233) of two half-tribes, each composed of eight gentes whose members claimed descent from a common ancestor. Descent was reckoned in the male line. No Kansa was permitted to marry a woman from a gens on his side of the circle, nor could he marry a kinswoman, however remotely related. The gentes were divided into seven phratries ("those who sing together"), of one to three gentes each. Their exact function is not clear, but two gentes comprising one phratry were connected with warfare and had the sole right to sing war songs. These gentes also had custody, in separate bundles, of the sacred war pipe and the war clamshell. Warriors, however, did not necessarily belong to these two gentes alone.

Chieftainship was hereditary, but real civil and military prestige came to the incumbent, as to any other individual, only from acts of bravery and generosity. In 1819, Say (James, 1823, I, p. 122)

wrote that the "hereditary principal chief . . . possesses nothing like monarchical authority, maintaining his distinction only by his bravery and good conduct." There were in addition to the principal chief, of whom Bourgmont mentions two, 10 or 12 lesser chiefs, but these commanded little respect from the people. According to Say, other than in intertribal or other matters of general import, the chief seems to have been largely a figurehead; he was occasionally appealed to for counsel, but controversies ordinarily were decided amongst themselves. Chouteau (Adams, 1904, p. 429), however, says the chiefs were "regarded as characters of great dignity," access to whom was a rare privilege to be paid for with horses, etc.

Visitors to the village were received, according to their importance, with much feasting and formality. Bourgmont was met by the grand chief and several subchiefs while still at some distance from the town; they welcomed him with speeches, smoked the calumet, danced and fired musketry, and prepared a feast for the Frenchmen. On reaching the village, the routine was repeated; Bourgmont was placed on a bison robe and carried to the chief's lodge to receive presents of skins and food. Thereafter the Frenchmen were taken from cabin to cabin for more feasting, speechmaking, and entertainment.

Of the games and amusements with which the Kansa, old and young, whiled away their leisure time, little information is extant. Outdoor sports included shinney, and the hoop and javelin game; indoors, there were various guessing games involving concealed objects, and a bowl and dice game, all affording opportunities for gambling (Skinner, 1915, p. 773). Chouteau (Adams, 1904, p. 431), speaking of the Mission Creek villages, says the men were inveterate gamblers. Well-to-do Indians were expected to put up horses, guns, robes, trinkets, and any other acceptable stakes; the games took place in the lodges of the chiefs, access to which might be denied a man who could afford to gamble but chose not to do so. The games were policed, and a player caught cheating was liable to a whipping or worse. Indians too poor to gamble were admitted as onlookers; sometimes they were permitted to entertain the guests with music to the accompaniment of the tambourine, deer-hoof or gourd rattles. or native flutes.

During Say's visit he and his party were treated to a performance of the dog dance (James, 1823, I, p. 135). The visitors, he says "had retired to rest in the lodge set apart for their accommodation, when they were alarmed by a party of savages, rushing in armed

Plate 5.—Kansa dog dance in an earth lodge at the former village 2 miles east of Manhattan, Kansas, on August 24, 1819. Samuel Seymour, artist; Long expedition. Courtesy Bureau of American Ethnology.

with bows, arrows, and lances, shouting and yelling in a most frightful manner. The Indians collected around the fire in the center of the lodge, yelling incessantly; at length their howlings assumed something of a measured tone, and they began to accompany their voices with a sort of drum and rattles. After singing for some time, one who appeared to be their leader, struck the post over the fire with his lance, and they all began to dance, keeping very exact time with the music. Each warrior had, besides his arms, and rattles made of strings of deer's hoof, some part of the intestines of an animal inflated, and inclosing a few small stones, which produced a sound like pebbles in a gourd shell. After dancing round the fire for some time, without appearing to notice the strangers, they departed, raising the same wolfish howl, with which they had entered; but their music and their yelling continued to be heard about the village during the night" (pl. 5).

Dorsey (1885, p. 678) says there were two war dances that might be put on before a war party set out; one was used in warm weather, the other at any time. Also, two dances could be used on the return party; one, the scalp dance was staged by the women, while the other was a male performance. Spencer (1908, p. 375) briefly describes a women's dance and a men's scalp dance, both staged in the late 1860's in connection with battles between the Kansa and Cheyenne; and Skinner (1915, p. 755) records several others.

As fighting men, the Kansa seem to have stood rather high in the estimation of early travelers, but unfortunately few details of their war practices, beyond the apparent relationship between mortuary rites and war parties, have been preserved. From remote times they warred, doubtless with occasional interludes of armed peace, against the Osage, Missouri, Iowa, Sac, Oto, Pawnee, Comanche, Wichita, and other of their neighbors. That the peace arranged in 1724 by Bourgmont between the Comanche, the Kansa, and other Missouri River tribes was anything more than an armed truce, is highly improbable. Lewis and Clark (Thwaites, 1904, VI, p. 84) observed in 1804 that they were at war with all nations, though sometimes at peace, and intermarrying, with the Oto and Missouri. And two years later, Pike says (1810, app. to pt. II, p. 53) they were at war "with none, if at peace with the Osage." In another place (ibid., p. 17), he says that "... in war, they are yet more brave than their Osage brethren, being (although not more than one third their number) their most dreaded enemies, and frequently making the Pawnees tremble."

And De Smet, many years later, says of the Pawnee (Thwaites, 1906, p. 207) that "... though six times more numerous than the Kanzas, they have almost on every occasion been conquered by the latter, because they are far inferior to them in the use of firearms, and in strength and courage."

Toward the whites their relationships were somewhat variable and not always amicable. With the French,[9] and later the Spaniards, at St. Louis, they carried on a lucrative trade in furs. In 1777, according to Cruzat (Houck, 1909, I, p. 139), two Frenchmen were licensed to the Kansa, returning with 150 packs of deerskins, 7 of beaver, and 3 of buckskin. By 1806, says Pike (1810, app. to pt. II, p. 53), the merchandise traded to the Kansa totalled five to eight thousand dollars, in return for 250 packs of deerskins, 15 of beaver, and 100 of otter. At the same time, Trudeau (Houck, 1909, II, p. 252) in 1798, says the Kansa are "at the least as great rogues" as the Osage.

Lewis and Clark in 1804 (Thwaites, 1904, VI, p. 85) call them "... a dissolute, lawless banditti; frequently plunder their traders, and commit depredations on persons ascending and descending the Missouri River. ..." And Major Long's report (James, 1823, II, p. 365) notes that "This tribe was formerly very troublesome to our traders, frequently robbing them of their goods, but since the establishment of the upper posts on the Missouri, they have become very friendly." Later, in Santa Fe trail days, the Kansa shared with others a certain notoriety as thieves and beggars, though rarely as armed disputants of the passage. As a tribe, the Kansa never took up arms against the American government. In 1864, it was reported by the government farmer that agricultural operations were hampered by the absence of "nearly a company" of young Kansa who were in active service with the Union army.

RELIGIOUS BELIEFS AND PRACTICES[10]

The Kansa entertained a belief, albeit one not easily formulated, in a supreme being or great spirit, whom they called Waucondah.[11] As

[9]Pike (1810, app. to pt. II, p. 13) relates a tale apparently told by Chtoka ("Wet Stone"), a Little Osage, who claimed to have been present at Braddock's defeat, with all the warriors who could be spared from the Grand and Little Osage villages. The Kansa were to participate, but did not arrive until the battle was over; the Otos were present. They were absent from their villages for 7 months, and were obliged to eat their horses on the return trip. This episode has not been independently confirmed, so far as I know.

[10]From James, 1823, I, p. 125; Dorsey, 1894, pp. 379-422; Morehouse, 1908, p. 358; De Smet, in Thwaites, 1906, p. 202 ff.

[11]This is, of course, the same supreme power that dominated the religious concepts of all the Dhegiha and Chiwere Siouan tribes. The name is perpetuated in Kansas by Wakonda, or Great Spirit, Spring on the Solomon River near Cawker City. McCoy (1840, p. 411) says the Kansa name for the Solomon (*Nepaholla*, water on the hill) derives from its nearness to this interesting mineral spring, and points out that the "Kausaus, Pawnees, and other tribes, in passing by this spring, usually throw into it, as a kind of conjuring charm, some small article of value" (cf. Patrick, 1906).

Say observed: "They say they have never seen the Master of life, and therefore cannot pretend to personify him; but they have often heard him speak in the thunder; they wear often a shell which is in honour, or in representation of him, but they do not pretend that it resembles him, or has anything in common with his form, organization, or dimensions. . . ."

Whether this being resided in the sun, the moon, or elsewhere was evidently a matter of doubt to the natives. Lesser spirits resided in the seasons, in light and darkness, in heat and cold, in fact everywhere—a sort of all-pervading animism.

Offerings were made to the morning star. Also, at the time of the first spring thunder-storm, the Thunder-being gens built a fire which they covered with green cedar to make a great smoke. Representatives of other gentes aided with prayers, and the mystery pipe and sacred clamshell were removed from their bundles. In addition to these propitiatory rites in spring, the Thunder-being was formerly appealed to before a war party set out.

It was believed that mystic enormous-headed beings dwelt in remote places, to which the unwary were enticed. A glimpse of these creatures drove the victim out of his mind, and he became a catamite.

The Kansa, in common with many other North American tribes, initiated their young men into manhood through the vision quest. The procedure was simple. The young brave sought out a lonely spot, and there abstained from food and water for four days, or more if necessary. The spirits were invoked by wailing and, often, some form of bodily torture, as the cutting off of the first joint of the little finger. The dream or vision induced by this prolonged self-mortification might provide the young man with invulnerability, or exceptional bravery in war, or outstanding prowess in other respects, and thus might profoundly affect his entire life. If he dreamed of an animal or other object, its likeness was painted on his shield, and these mystery objects were frequently depicted also on the tipi covers. Visions to insure superhuman assistance, as before departure of a war party, were also sought, but presumably with less extreme self-torture.

Of other rites and ceremonies to propitiate, or to enlist the aid of, the supernatural, there are few records. Formerly, whenever a permanent village was set up by the Kansa and Osage, a certain number of fireplaces had to be consecrated before the ordinary fireplaces could be made. The consecrated hearths were in two parallel rows, beginning at the west and ending at the east; the Kansa had seven fireplaces in one row and six in the other. In former days,

too, according to Dorsey, the Kansa removed the hearts of slain foes and placed them in the fire as a sacrifice to the four winds. Also, they are said to have pierced themselves with knives and splinters of wood, the while offering bits of their flesh to the Wakondas. This is somewhat reminiscent of plains sun-dance procedures. Morehouse says that the sun-dance was "originally a religious ceremony. . . ." among the Kansa.

Of shamanistic practices, we have the observation by Dorsey (1894, p. 418) that there were formerly 10 shamans in the tribe. All had small round pebbles which they "blew from their mouths" against persons whom they "shot in a mysterious manner."

The sacred objects of the tribe included pipes, a clam-shell, and various roots used as medicines; all, according to Dorsey, were believed to have been brought from the east by the ancestors of the Kansa. The sacred clamshell, "made like the face of a man, with eyes, teeth, etc. . . ." came from "the great water at the east." Sacred pipe and clamshell, as elsewhere indicated, were kept in special bundles cared for by the war gentes.

Morehouse states that the Kansa never were persuaded of the superiority of the white man's religion, that they had fewer religious ceremonies than many other tribes, and were exceedingly reticent about discussing either their beliefs or their rituals.

CONCLUSION

Despite the scattered and very fragmentary nature of the published information on the Kansa Indians, it is clear that they were in general a representative village group of the eastern plains. In what we know of their social and political organization and their religious practices may be seen a close similarity to the customs of their semi-sedentary Siouan-speaking neighbors, notably the Osage. As regards material culture—the subsistence pattern, architectural concepts, and their various arts and industries—they shared a mode of life characteristic of many nearby non-Siouan tribes as well. In the not long distant past, they may well have been a prairie or even a woodland people; but from the time of their first recorded meetings with the whites a strong plains bias existed.

That the future will witness any great increase in our knowledge of the non-material aspects of Kansa life seems unlikely, barring the discovery of yet unknown manuscript materials or early historical documents. Unfortunately, too, very few aboriginal products of Kansa craftsmanship seem to have found their way into museum collections. Systematic archeology at the earliest known sites can

probably partially fill this gap in our information, insofar as it concerns the non-perishable items of material culture, and will undoubtedly amplify our knowledge of the relationships at an early date with whites and with other tribes.

BIBLIOGRAPHY

ABEL, ANNA H. 1904. Indian reservations in Kansas and the extinguishment of their title. Trans. Kans. St. Hist. Soc., v. 8, pp. 72-109.

ADAMS, FRANKLIN G. 1904. Reminiscences of Frederick Chouteau. Trans. Kans. St. Hist. Soc., v. 8, 1903-4, pp. 423-434.

ANON. 1820. Notes on the Missouri River, and some of the native tribes in its neighborhood. By a military gentleman attached to the Yellow Stone expedition in 1819. The Analectic Magazine, new series, vol. 1, no. 4 (April), pp. 293-313; and vol. 1, no. 5 (May), pp. 347-375. Philadelphia.

BLAIR, EMMA H. 1912. The Indian tribes of the Upper Mississippi valley and region of the Great Lakes. 2 vol. Cleveland.

BOLTON, H. E. (editor). 1916. Spanish exploration in the Southwest, 1542-1706. New York.

BUSHNELL, DAVID I., JR. 1922. Villages of the Algonquian, Siouan, and Caddoan tribes west of the Mississippi. Bur. Amer. Ethnol., Bull. 77. Washington, D. C.

CATLIN, GEORGE. 1841. Letters and notes on the manners, customs, and condition of the North American Indians. 2 vol. London.

DE SMET, P. J. 1843. Letters and sketches with a narrative of a year's residence among the Indian tribes of the Rocky Mountains. Philadelphia.

DORSEY, J. O. 1885. Mourning and war customs of the Kansas. Amer. Naturalist, v. 19, no. 7, pp. 670-680.

——— 1886. Migrations of Siouan tribes. Amer. Naturalist, v. 20, no. 3, pp. 211-222.

——— 1894. A study of Siouan cults.. 11th Ann. Rept., Bur. of Ethnol., pp. 351-544. Washington, D. C.

——— 1897. Siouan Sociology. 15th Ann. Rept., Bur. of Ethnol., pp. 213-244. Washington, D. C.

DU PRATZ, LE PAGE. 1774. The history of Louisiana. London.

GREGG, JOSIAH. 1844. Commerce of the prairies. 2 vols. New York.

HODGE, F. W. (editor). 1912. Handbook of American Indians north of Mexico. Bur. Amer. Ethnol., Bull. 30, pts. 1-2. Washington, D. C.

HOUCK, L. 1909. The Spanish regime in Missouri. 2 vols. Chicago.

JAMES, EDWIN. 1823. Account of an expedition from Pittsburgh to the Rocky Mountains, performed in the years 1819-20. . . . under the command of Major Stephen H. Long. 2 vols. Philadelphia.

LA FLESCHE, FRANCIS. 1924. Omaha bow and arrow makers. Internat. Congr. Americanists, Proc., v. 20, pt. 1, pp. 111-116.

McCOY, ISAAC. 1840. History of Baptist Indian missions. Washington and New York.

McGEE, W. J. 1897. The Siouan Indians. 15th Ann. Rept., Bur. Ethnol., pp. 153-204.

MARGRY, PIERRE. 1867. Relations et memoires inedit, 376 pp.

——— 1875-86. Découvertes et établissements des Francais dans l'ouest et dans le sud de l'Amérique Septentrionale (1614-1754). Mémoires et documents originaux, pts. I-VI. Paris.

MOREHOUSE, GEO. P. 1904. Along the Kaw trail. Trans. Kans. St. Hist. Soc., v. 8, pp. 206-212.

——— 1908. History of the Kansa or Kaw Indians. Trans. Kans. St. Hist. Soc., v. 10, pp. 327-368.

MORSE, JEDIDIAH. 1822. A report to the Secretary of War of the United States, on Indian affairs, comprising a narrative of a tour performed in the summer of 1820. . . . New Haven.

PATRICK, G. E. 1906. The Great Spirit Spring. Kans. Acad. Sci., Trans., vol. 7, pp. 22-26.
PAULLIN, C. O. 1932. Atlas of the historical geography of the United States. Carnegie Inst. of Washington Publ. 401.
PIKE, ZEBULON M. 1810. An account of expeditions to the sources of the Mississippi, etc. Philadelphia.
REMSBURG, GEO. J. 1911. Recent examinations in Salt Creek valley in eastern Kansas. The Archeological Bulletin, v. 2, no. 3, pp. 66-67.
——— 1919 ? An old Kansas Indian town on the Missouri. Plymouth, Iowa (privately printed). Also printed in P. L. Gray's Doniphan County History, 1905, pp. 148-155.
SCHOLES, F. V. and H. P. MERA. 1940. Some aspects of the Jumano problem. Contrib. to Amer. Anthrop. and History, no. 34. Carnegie Inst. of Washington, Publ. 523, pp. 265-299.
SCHOOLCRAFT, H. R. 1851-5. History, condition, and prospects of the Indian tribes of the United States. 5 vols. Philadelphia.
SIBLEY, GEORGE C. 1922. "From a journal to the Pawnee and Kansas Villages, undertaken by an officer of the Factory on the Missouri." Louisiana Gazette, May 16, 1812; reprinted in Nebr. Historical Publications, vol. 20, pp. 5-11, Lincoln, 1922.
SKINNER, ALANSON. 1915. Societies of the Iowa, Kansa, and Ponca Indians. American Museum of Natural History, Anthrop. Papers, v. XI, pt. IX, pp. 741-775. New York.
SPENCER, JOAB. 1908. The Kaw or Kansas Indians: their customs, manners, and folk-lore. Trans. Kans. State Hist. Soc., v. X, pp. 373-382, 1907-8. Topeka.
STRONG, W. D. 1935. An introduction to Nebraska archeology. Smithsonian Misc. Coll., v. 93, no. 10. Washington.
THWAITES, R. G. (editor). 1904. Original journals of the Lewis and Clark expedition, 1804-6. 7 vols.
——— 1906. Early Western Travels. Vol. 27. Cleveland.
TUCKER, SARA JONES. 1942. Indian villages of the Illinois country. Illinois State Museum, Scientific Papers, vol. II, pt. 1, atlas. Springfield.
WEDEL, W. R. 1938a. Inaugurating an archeological survey in Kansas. Explor. and Field-Work of the Smithsonian Institution in 1937, pp. 103-107.
——— 1938b. Some problems and prospects in Kansas prehistory. Kansas Historical Quarterly, v. 7, no. 2, pp. 115-132. Topeka.
——— 1940. Culture sequence in the central Great Plains. Smithsonian Misc. Coll., v. 100, pp. 291-352.
——— 1941. Environment and native subsistence economies in the central Great Plains. Smithsonian Misc. Coll., v. 101, no. 3.

The Editor's Page

Transactions
of the
Kansas Academy of Science

Published Quarterly
by the
KANSAS ACADEMY OF SCIENCE
(Founded 1868)

OFFICERS

Claude W. Hibbard, Lawrence, President.
Donald J. Ameel, Manhattan, Secretary.
S. V. Dalton, Hays, Treasurer.

VOL. 49, No. 1 JUNE, 1946

ROBERT TAFT, *Editor*

William Allen White was born in Emporia on February 10, 1868. Seventy-six years later he died in the town of his birth on Kansas Day, January 29, 1944. His life span of better than three quarters of a century, therefore, covered most of the history of Kansas as a state. His life story, *The Autobiography of William Allen White* (The Macmillan Company, New York, 1946, 669 pages, $3.75), then, is not only an account of individual development but it is an informal and inside history of the state, with very personal recollections of national and international interludes thrown in for good measure. Mr. White's friends, his critics, and all other Kansans should find profitable reading in his story, written with the candor of age, but without the pomposity of success. But the book is far more than profitable reading. It is entrancing. It is the story of a day that is gone, written by a participant who enjoyed life to the full and who could make his enjoyment articulate to others but could at the same time always stick to the realities of life. "I was just a fat slob", he writes as he looks backward and views himself as a young man beginning his career with the Emporia *Gazette,* "who was trying to hide, under the exuberance of youth and its strength and force, an oleaginous complacence which was satisfied with beaming and grinning and not above a little clowning now and then, more or less conscious, in an attempt to hide my obvious shortcomings. I was an extrovert, glad-handing my way through a vale of tears." Or if this self analysis is not enough to endear him to all save the priggish, his admission "I am not naturally a good man, but I have been scared to death so many times that I have learned regretfully but definitely that honesty is the best policy" should make him brother to us all.

The joy of reading this book should be shared by all Kansans. These few excerpts from the *Autobiography* (and those on page 50) are but enticing samples. The editor, however, wishes to use one more quotation as it illustrates a point that has been consistently ignored by most re-

viewers of the book. One of the most important stepping stones to White's success as a national figure was his editorial "What's the Matter with Kansas?" Written in 1896 as an attack on the Populist party, it was used as Republican campaign literature and played a very real part in the election of McKinley. But read what Mr. White writes nearly fifty years later as he views his part in that election:

> Perhaps if I had known the real significance of that election, perhaps if I had realized that it was the beginning of a long fight for distributive justice, the opening of a campaign to bring to the common man—the man lacking the acquisitive virtues, the man of one talent—a larger and more equitable share in the common wealth of our country, I should have been more consciously ashamed of my potential attitude than I was; for I was constitutionally and temperamentally, by blood and inheritance on both sides of my family, a friend of the underdog. But some way, in those days, I was blind to the realities. My college education, my reading in sociology and in science, to keep abreast and be worthy of fellowship with Vernon Kellogg, did not teach me to see the truth all about me in the middle nineties. I saw the mange on the underdog and did not realize its cause. Perhaps if Bryan had won and the underdog had been fed up a little and had been top dog, I should have respected him more heartily. I wonder. I doubt it. Perhaps I shrink from the truth, even now, looking back at those days.

If White's viewpoint had shifted this much in fifty years it is indeed a pity that the last twenty years of his life have had to be outlined by his son in the last twenty pages of the book; presumably (although it is nowhere so stated) because time ran out on Mr. White of the Emporia *Gazette*—as it will on us all.

Waldo R. Wedel, the author of "The Kanza Indians" featured in this issue of the *Transactions*, was born in Newton, Kansas, thirty-seven years ago. His father, Professor P. J. Wedel, emeritus professor of chemistry at Bethel College, was one of that large group of Russian Mennonites who came to Kansas in 1874 and who have contributed so largely to the development of Kansas in many ways. Dr. Wedel's interest in archeology dates back to his boyhood days

DR. WALDO R. WEDEL

in Harvey County where he, with a companion, explored the streams and fields for the arrowheads left by our red predecessors in Kansas. Wedel's companion on these trips was Emil W. Haury whose father, too, taught in Bethel College, founded by the Mennonites. Haury as a young man went to the University of Arizona (where he is now

head of the department of archeology) for formal training in archeology. Dr. Wedel in time followed his companion to that institution and received his bachelor's degree from Arizona in 1930. His graduate work was done at the University of Nebraska and the University of California; from the latter school he received his doctorate in 1936.

Following his graduation from California, Dr. Wedel entered service with the United States National Museum where he is now associate curator of archeology. His most extensive field explorations have been in the Central Plains states—Kansas, Nebraska, the Dakotas, and northwestern Missouri, although he has also taken part in fieldwork in Arizona, California, old Mexico and in the Potomac Valley. At present he hopes to direct several field parties in extensive explorations of the Missouri River Valley in connection with the program of development for the Valley which has been long under discussion.

Among Dr. Wedel's extensive contributions to archeological literature are *An Introduction to Pawnee Archeology*, Bulletin No. 112 (1936), Bureau of American Ethnology; "The Direct Historical Approach in Pawnee Archeology", "Environment and Native Subsistence Economics in the Central Plains" and many other professional papers appearing in the *Smithsonian Miscellaneous Collections* since 1937.

* * *

Mr. J. C. Mohler, secretary of the Kansas State Board of Agriculture, has suggested that a national or state park be created in the Bluestem Hills. The Bluestem Hills, more commonly called the Flint Hills, constitute one of the world's greatest pasture lands and in its vernal season can scarcely be equalled for beauty. Mr. Mohler's suggestion that a part of this area be set aside where Kansans and visitors alike could view the majestic peacefulness of the Hills deserves the hearty support of the Academy.

* * *

All book reviews which have previously appeared in the *Transactions* since it became a quarterly have been written by the editor. This statement is made solely for the purpose of directing brick-bats in the right direction. In this issue, Dr. F. D. Farrell, President-emeritus of Kansas State College, and Dr. A. W. Davidson of the University of Kansas have both contributed reviews which can be identified by the initials of each. This second statement is made solely for the purpose of directing bouquets in the right direction.

* * *

The editor is unusually proud of this issue of the *Transactions* and he trusts that all members of the Academy will feel an equal pride in it. The outstanding articles by Dr. Wedel, by President Breukelman, and by Dr. Frye are all directly concerned with Kansas, as are the annual notes of Professor Agrelius. To keep us from regarding Kansas as the center of the universe, however, we have Lieutenant Downs' observations on the bird life of Tinian, half the world away. Lt. Downs, a resi-

dent of Emporia and now a graduate student at the University of Kansas, found that even war itself could not wholly distract him from his scientific pursuits. Still another member of the Academy, Sgt. Morton Green, is, like Lt. Downs, to be congratulated on his perseverance in the interests of science, for both have made contributions to the *Transactions* while in the service of their country. (Sgt. Green's contribution will be found in the March, 1945, issue of these *Transactions.*)

Scientific News and Notes of Academy Interest

Items for this column are solicited from all Academy members. For inclusion in any given issue they should be in the editor's hands at least three weeks before our publication dates, namely the fifteenth of March, June, September and December.

The campaign for increased Academy membership last year brought gratifying results and we now exceed by four hundred members the previous high water mark in our membership list. The most recent count of our mailing list shows a total of 1020 members who receive the *Transactions.* Among recent additions are over thirty oil geologists of the state. We welcome them to membership and invite them to take an active part in our affairs.

With the influx of science teachers, graduate students, and industrial scientists into the state, we should, if each will do his share, reach a still higher mark during the coming year.

The following members have been elected to the Society of Sigma Xi, honorary science organization, by the two Kansas chapters of the Society during the current year:

Kansas State College, Manhattan
- Full members
  - Charles H. Brett, *Entomology*
  - Charles H. Harned, *Geology*
  - Gerald Pickett, *Applied Mechanics*
  - Bernard B. Riedel, *Zoology*
  - Charles L. Wisseman, Jr., *Zoology*
- Alumni members
  - Arvid A. Anderson, *Civil Engineering*
  - Dale S. Romine, *Agronomy*
- Associate members
  - Dean S. Folse, *Zoology*
  - Leon G. Lungstrom, *Entomology*
  - Eula Frances Morris, *Food Economics*
  - Edward J. Rambie, *Mechanical Engineering*

University of Kansas, Lawrence
- Full members
  - H. Leon Bradlow, *Chemistry*
  - Kenneth R. Hoffman, *Chemistry*
  - William H. Schechter, *Chemistry*
  - Stephen Stephanou, *Chemistry*
  - Edison Greer, *Mathematics*
  - David Rapaport, *Psychology*
  - Preston R. Clement, *Electrical Engineering*

The Academy offers its congratulations to each new member and wishes for each a long and fruitful career in science.

Dr. P. S. Albright of the University of Wichita and chairman of the Academy committee on research awards announces that funds for awards are still available. Applications for awards are

invited from any member of the Academy and should be directed to Dr. Albright.

Dr. R. E. Mohler, professor of biology at McPherson College, now spending a semester's leave in California, reports that he has seen countless tons of beautiful jasper in the Mohave Desert. The best areas for finding jasper, Dr. Mohler states, are on highway 66 between Barstow and Ludlow, California. He further writes "If one will leave the highway just north of Pisgah Crater he will discover at once that he is standing in a great jasper region where will be found jasper of beautiful colors and color combinations: red, yellow, green, blue, and gold. Much of it will take a high polish and if one wished, enough could be collected to build not one but many, many houses. I do not expect that anyone will collect enough to build a house but jasper is expensive if bought from a supply house; here it is yours in abundance if you will but add this interesting little expedition to your next trip through the Mohave Desert."

Dr. G. B. Price, professor of mathematics at the University of Kansas, has been awarded a Guggenheim fellowship for the coming year. Dr. Price, one of the 60 former servicemen who received awards for post-service fellowships, will investigate a "Theory of Functions of Several Real Variables."

Dr. W. T. Stratton retires September first as head of the department of mathematics at Kansas State College, Manhattan, after nine years of administrative duties but will continue as a full-time member of the department. Dr. Stratton will be succeeded as department head by Dr. Ralph G. Sanger, dean of students in the division of physical sciences at the University of Chicago. Dr. Sanger has been a member of the University of Chicago mathematics faculty since 1928.

Mr. Charles L. Fergus, a graduate of Ottawa University in 1940 and later of the University of Kansas is now enrolled in the graduate school of Pennsylvania State College where he is working towards his doctorate in the field of mycology. Mr. Fergus served in the armed forces as a naval lieutenant until his discharge last September.

Beaver, once practically extinct in Kansas, are increasing in numbers to such an extent that the Forestry, Fish and Game Commission has undertaken, in the last few years, a trapping program at the request of farmers. Complaints have been registered with the Commission that the beaver have been guilty of damage to farm crops and farm property. During the winter of 1945-46, Director Dave Leahy of the Commission reports that trappers captured 214 beavers. The average price obtained for the beaver pelts was $31.00, a rather low average because there were many kits in the lot offered for sale.

Most of these beaver were taken along the Solomon and Republican Rivers of North-central

Kansas and from Prairie Dog Creek and other small streams in Wallace, Decatur, Sherman, and Rawlins Counties. A few were taken in Atchison, Leavenworth, Douglas and Riley Counties.

Director Leahy states "The take of beaver has been increasing from year to year and it can be definitely said that there is a very large beaver population in Kansas."

The State Geological Survey at the University of Kansas, the sixth research center to be considered in these *Transactions,* was authorized by the state legislature in 1889 and was organized shortly thereafter by the late Professors Erasmus Haworth and S. W. Williston. It had a fluctuating but nonetheless continuous existence from that time to the present. Two short-lived periods of state-supported geologic work occurred in the 1860's when B. F. Mudge and S. G. Swallow each served as state geologist for one year. The State Geological Survey was authorized by the legislature "to make as far as possible a complete geological survey of the state of Kansas, giving special attention to any and all natural products of economic importance, in order to determine the character, location, and amount of such products, and to prepare reports on the same as hereinafter prescribed." The Survey operates as a separate division of the University, and although some members of the technical staff divide their time by teaching in the college of liberal arts and the engineering school, the administration of the Survey is separate from that of any academic department. Funds are provided by the legislature as a separate item in the University appropriation and the Chancellor is designated as Director, *ex officio.*

Electric and gas fired kilns and control panel in the industrial minerals laboratories of the State Geological Survey at the University of Kansas.

In recent years the State Geological Survey has been organized into several divisions sup-

ported wholly by state funds; two that cooperate on an equal basis with the United States Geological Survey; one that cooperates with the State Boards of Health and of Agriculture and with the Federal Survey; and one that cooperates on a nonfinancial basis with the United States Bureau of Mines. The role of the Geological Survey within the state might be compared to the Agricultural Experiment Station and its research programs, as the Survey attempts, within the limitations of its funds, to serve the mineral industries of Kansas. As Kansas has for many years consistently ranked among the top ten mineral producing states of the nation, it can be seen that this is by no means a small job.

There are seven major divisions of the Survey, four of which include: (1) the stratigraphic and areal geology division which carries on much needed basic studies on the geology of the state; (2) the division of subsurface (oil and gas) geology which makes investigations of strata penetrated in wells, collects well logs—the files contain 54,000—and well cuttings which are filed both in Lawrence and in a branch office in Wichita for the convenience of the oil industry, and collects and files other data concerning the rocks below the surface; (3) the mineral resources division which includes the well-equipped industrial minerals and ceramics laboratory (part of which is shown in the photograph), a southeastern Kansas field office located on the campus of Pittsburg State Teachers College, and a section which cooperates with the United States Bureau of Mines in the collection of mineral statistics; (4) a division of publications, records, and drafting which prepares manuscripts for publication and distributes the more than 200 reports that have been published by the Survey and an even larger number of maps and charts.

In addition two divisions, supported jointly by the State and Federal Geological Surveys, include (1) topographic mapping, which surveys, prepares, and publishes the detailed contour maps of various parts of the state, and (2) mineral fuels, which carries on special research projects on the subsurface character of the oil and gas producing rocks of the state.

Another cooperative division, the largest in the organization, is concerned with the study of underground water. This work is done jointly by the State and Federal Geological Surveys, with the cooperation of the Division of Water Resources of the State Board of Agriculture and the Division of Sanitation of the State Board of Health. A drilling rig capable of penetrating 1,000 feet below the surface and geophysical equipment are operated by this division; periodic measurements of water level in many parts of the state are made.

In addition to investigating many aspects of the geology and mineral resources of the state and making the results of these investigations available to the public in the form of published reports, the Geological Survey maintains facilities for special services to the people of Kansas.

Each year staff members answer many inquiries which reach the office by mail and confer with many interested persons who bring in problems ranging from the identification of a fossil or mineral specimen to aid in the development of a water well or limestone quarry. A list of publications will be supplied free of charge to any interested person by addressing the State Geological Survey, Lawrence, Kansas.

Dean L. E. Call, Kansas State College, Manhattan, will head an agricultural commission to the Philippine Islands at the request of the office of foreign agricultural relations of the United States Department of Agriculture. The presence of the commission was solicited by the government of the Commonwealth of the Philippines for consultation on agricultural readjustment and rehabilitation necessitated by the ravages of war. Dean Call will leave for the Philippines on June 15th and will be gone for six months.

Mr. John M. Olmsted, a graduate of Ottawa University in 1940, is now enrolled as a graduate student in plant pathology at the University of Minnesota. Major Olmsted served with the paratroopers during the war and took part in the Normandy invasion.

Dr. Walter M. Kollmorgen has been appointed associate professor of geography at the University of Kansas succeeding Professor C. J. Posey who retired in February, 1946. Dr. Kollmorgen is a graduate of the University of Nebraska and received his doctorate from Columbia University in 1940. For the past six years he has been an agricultural economist with the Bureau of Agricultural Economics, U.S. D.A.

Dr. Waldo B. Burnett has been appointed director of the University of Wichita Industrial Research Foundation. Dr. Burnett goes to Wichita from the Tubize Rayon Corporation, Rome, Georgia, where he was supervisor of research and development dealing with the production of viscose products; prior to his connection with Tubize he was a senior industrial fellow at Mellon Institute. Dr. Burnett is a graduate of Southern Methodist University and received his doctorate in chemistry from the University of Illinois in 1923.

The Dinosaur Book by Edwin H. Colbert (American Museum of Natural History, New York, 1945, 156 pages, $2.50) is an interesting and popular guide and handbook of the ancient ruling reptiles and their relatives. Numerous excellent diagrams and illustrations make this book of particular value to the non-professional and a half-dozen cartoons "Dinosaurs in the Public Eye" lend a humorous turn that is all too frequently lacking in so-called handbooks. The founders of paleontology and the paleontologists' methods of work are discussed in individual chapters and also add human interest to the volume. Sources of reading for additional information form the concluding chapter.

Wildlife Conservation in Kansas by Edwin O. Stene, published in these *Transactions,* March, 1945, has been reprinted by the

Bureau of Government Research as their Bulletin No. 3. The bulletin has been made available for distribution to applicants for fish and game licenses through the county clerks of Kansas. Any reader of the *Transactions* may obtain a copy by addressing Dr. Ethan P. Allen, Director, Bureau of Government Research, University of Kansas, Lawrence.

Miss Wanda Power, for the past year instructor in botany at William Jewell College, will continue her graduate studies at Western Reserve University beginning in September.

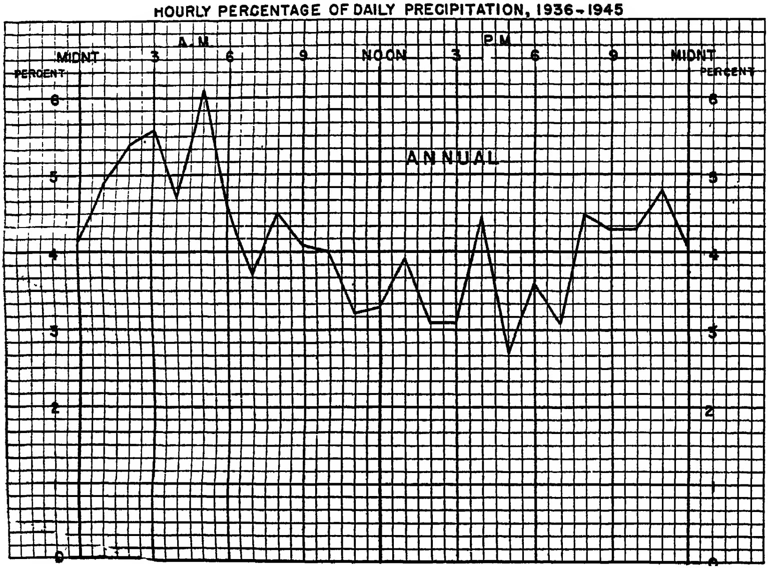
Analysis of Topeka precipitation by hours of the day, which is undoubtedly representative for at least the eastern half of Kansas, shows that more than 56% falls between 6 p.m. and 6 a.m., with one pronounced peak at 5 a.m. and another at 11 p.m. The least rainy part of the day is between 11 a.m. and noon, 2 p.m. and 3 p.m., and again near 5 p.m., with an afternoon peak near 4 p.m.

This distribution of the day's fall of moisture is a favorable one for Kansas. Rains falling at night moisten the soil more effectively than those that occur during the daytime, when evaporation is high. Also, the comparative absence of rain during the middle of the day gives a better opportunity for outdoor work.

It has often been said that it rains

TOPEKA, KANS.

HOURLY PERCENTAGE OF DAILY PRECIPITATION, 1936-1945



The graphical data reproduced in the above diagram is part of the compilation of data now being prepared at the U. S. Weather Bureau Office, Topeka, Kansas, for the forthcoming publication "The Climate of Kansas." Mr. S. D. Flora writes concerning it:

nights and Sundays in Kansas so the hired men can rest. There is no reason to think rain is more likely on Sundays than on any week day but it is certainly more frequent at night than during the daytime.

As events make it increasingly evident that scientists must learn more and do more about

government, a new edition of a famous old book on the subject of democracy may appropriately be called to the attention of members of the Academy. The book is *Democracy in America,* by Alexis de Tocqueville. The new edition was published in 1945 by Alfred A. Knopf, New York. The retail price of the two volumes is $5.25.

Originally published in 1835, *Democracy in America* has been reprinted repeatedly and quoted extensively during more than a century. The 1945 edition is particularly timely now, when popular government is undergoing an unusually severe test. An excellent 100-page introduction by Phillips Bradley heightens the reader's enjoyment and appreciation and increases his understanding of the book.

Keen, observant, sincere and able, de Tocqueville spent nine months in the United States during Jackson's first administration. The time was propitious. Democracy was rampant here and "the West" for the first time was in the saddle. The 26-year-old Frenchman, eyes and ears open and notebook in hand, visited as far west as Green Bay, as far south as New Orleans and as far northeast as Boston. He visited 18 of the 24 states of which the Union was then composed.

Returning to France in 1832, de Tocqueville devoted three years to the preparation of volume one and five more years to volume two. His book is a description of what popular government in the United States was and did in 1831 and a discussion of how it came to be and of why and how it did as it did. To read the book helps us to "see ourselves as others see us." The book is valuable for those who wish to improve their perspective and increase their understanding in the field of government.—F.D.F.

Mr. Norman Gerhold, a graduate of Ottawa University in 1940, is now enrolled in the graduate school of Iowa State College, majoring in plant pathology. Mr. Gerhold received his discharge from the armed forces last October after serving in the U. S. Navy as a lieutenant.

Mr. Ralph Burress, a graduate of William Jewell College, is continuing graduate study in animal conservation at the University of Missouri after having received his discharge from the Army.

Mr. Walter W. Dalquest has joined the growing staff of the Museum of Natural History, University of Kansas, as field assistant. Mr. Dalquest, a graduate of the University of Washington, has been spending the past several months in Mexico collecting birds and mammals for advanced study in the Museum. Several hundred specimens have been sent to the Museum by Mr. Dalquest including many tropical and semitropical birds of brilliant plumage and curious red and brown squirrels.

Mr. Joao Moojen, curator of mammals, National Museum of Brazil, Rio de Janeiro, has been granted a fellowship by the Brazilian government for advanced study in mammology. Mr. Moojen is now in residence at the

University of Kansas where he plans to spend his fellowship period of two years.

The curious title of *The River Mathematics* (Henry Holt and Co., New York, 1945, 401 pages, $3.75) is metaphorical; the author, Alfred Hooper, depicts the development of mathematical ideas from their primitive prehistoric origins to their present comprehensiveness, in terms of the growth of a river from a tiny stream into a broad estuary. He pictures the stream as dividing near its source into two branches, number reckoning on the one hand, geometry on the other; these branches are shut off from each other by a barrier which is broken down only at the dawn of modern times, when they merge, in the 17th century, into trigonometry, analytical geometry, and calculus.

The author's method of exposition is a combination of the historical and the practical approach. After outlining the origin and development of a mathematical idea, he proceeds to give meticulous instructions as to its use, followed by illustrations of the types of practical problems to which it is applicable. The explanations are clear and specific, the diagrams copious, well drawn, and, for the most part, easily intelligible. Detailed instructions on the use of logarithms and the slide rule are included, as are discussions of such practical matters as the application of the triangle of velocities to air navigation, and the relation between longitude and time.

The reviewer finds it somewhat difficult to decide just what class of readers would be served by this book. It seems certain that one who required the detailed explanation of the significance of fractions, the directions for multiplication and division of decimals, and the discussion of the metric system, which are included in the first few chapters, would scarcely be able to follow the development of formulas for the sine of the sum or difference of two angles, for example, or the composition of vectors to determine the course of an airplane, or the very brief discussion of integration which is given in the last chapter—not to mention the extraction of cube root by the application of DeMoivre's theorem, which appears in the appendix.

Nevertheless, the book is worth reading for the sidelights that it throws upon the history of methods of calculation, as well as for the fragments of unfamiliar information which one comes upon unexpectedly—such, for example, as the odd derivation of the word "sine", the illustrations of the use of the parabola and the ellipse in civil engineering and architecture, or the method of determining the area of a rectangular plate by means of a chart consisting of equilateral hyperbolas.

The motivation for the book appears to be entirely utilitarian, and it makes no appeal to the imagination and scarcely any reference to philosophy; yet the author is not without insight into the wider implications of mathematics, for we find on the last two pages not only the statement that, ". . . the mathematical abstraction of today has a hab-

it of developing into the commonplace, practical aid-to-living of tomorrow", but also, "It [mathematics] opens even to ordinary men and women a highly developed system of accurate and honest thinking, and with it a stabilizing influence in an age of doubt and perplexity".

—A.W.D.

Dr. H. J. Peppler, lately Major Peppler of the U.S.A., has joined the research staff of the Carnation Milk Company, Milwaukee, Wisconsin. Previous to his entry into the army, Dr. Peppler was a member of the department of bacteriology, Kansas State College, Manhattan.

Dr. Lloyd Berg, formerly of the Gulf Research and Development Company, Pittsburgh, Pennsylvania, has been appointed associate professor of chemical engineering at the University of Kansas. He began his duties during the current semester. Dr. Berg is a graduate of Lehigh University and received his doctorate from Purdue University in 1942.

The growing interest in the question of the adequacy of our petroleum resources, an interest accentuated by the lavish use of gasoline and other petroleum products in the conduct of the recent war, warrants a careful reading of *Our Oil Resources* published in 1945 by McGraw-Hill. The book is a symposium by a group of leading oil company officials, including Wallace E. Pratt, whose interesting and informative book, *Oil in the Earth,* was published by the University of Kansas Press in 1943. The ten chapters of *Our Oil Resources* are composed of authoritative discussions of the role of private enterprise, American companies in foreign oil fields, conservation of oil and gas, petroleum technology, oil and gas reserves, coal and shale in relation to petroleum products, petroleum in the public domain and in Federal reserves, the capital requirements of the oil business, and an enlightening summary discussion by L. M. Fanning, editor of the symposium. Although the book may be regarded by some as an *ex parte* statement of the case, it certainly is written by able and experienced men who know whereof they speak and whose data and documentation are convincing. The retail price of the book is four dollars.—F.D.F.

Dr. F. E. Hoecker, associate professor of physics, University of Kansas, will take part this summer in "Operation Crossroads" near Bikini Atoll. Dr. Hoecker will leave Lawrence the middle of July and will be attached to the radiological safety section during the atomic bomb tests. He will return to the University in September.

Dr. Jacob Uhrich of the department of biology, Kansas State Teachers College, Pittsburg. has accepted a position as head of the department of biological science, Trinity College, San Antonio, Texas. Dr. Uhrich began his work at Trinity on June first.

Miss Dorothea S. Franzen of the department of zoology, University of Kansas, spent three weeks during the past April in

intensive studies of pupilled snails in the collections of the U. S. National Museum, Washington, of the Philadelphia Academy of Sciences and of Carnegie Museum in Pittsburgh, Pa.

Dr. Frank C. Gates, department of botany, Kansas State College, Manhattan, left June 6th to teach plant ecology for the summer in the Biological Station of the University of Michigan, Cheboygan.

Judging from reports turned in to the editor by members of the Academy at the Emporia meeting, Kansas was well represented at the spring meeting of the American Association for the Advancement of Science in St. Louis. Some forty members reported attendance and probably there were still other Kansans present.

A Malariologist in Many Lands by Marshall A. Barber (University of Kansas Press, 158 pages, 1946, $2.50) is the personal story of a distinguished Kansas scientist and an honorary member of the Academy. Dr. Barber's studies of anopheles in practically every continent and in many countries have brought "incalculable benefit to millions of people"; a judgment pronounced by Dr. Paul R. Russell of the Rockefeller Foundation. Dr. Barber's account is simply written and gives an understandable account of a disease which is the cause of a considerable fraction of the world's sickness and death, and of its method of transmission and of prevention.

Dr. William J. Argersinger has been appointed assistant professor of chemistry at the University of Kansas and will begin his duties with the present summer session. Dr. Argersinger is a graduate of Cornell University, having received his bachelor's degree from that institution in 1938 and his doctorate in 1942. After a year's instructorship at Cornell, he joined the staff of the Monsanto Chemical Company on one of the many war research projects that led to the development of the atomic bomb.

An aeronautical chart of the Kansas River, 20x28 inches, scale 1:100,000 has been published recently by the U. S. Coast and Geodetic Survey. The map may be obtained by addressing the U. S. Coast and Geodetic Survey, Washington, D. C. for a charge of 25 cents. The order number is C 4.9/8:360.

Mr. Leo Brown, after completing his master's degree in botany and zoology at Fort Hays Kansas State College is now employed by the U. S. Soil Conservation Service. Mr. Brown is stationed at present at Mankato, Kansas.

The physics department of Baker University, Baldwin, recently received a complete X-ray outfit as a gift from Bethany Hospital, Kansas City, Kansas.

Dr. Donald J. Ameel, department of zoology, Kansas State College, Manhattan, has published in a recent issue of *Herpetologica* (volume 3, pp. 49-56, 1946) "An Annotated List of Papers on Herpetology from the Transactions of the Kansas Academy of Science." The list includes 56 papers on fossil and

living forms, the first of which was published in 1877.

Handbook of Lizards, Hobart M. Smith (Comstock Publishing Co., Ithaca, New York, 1946, 557 pages, $5.75), the first extensive treatise on the lizards of the United States and Canada, is a book in which all Academy members may take pride. It is written by an Academy member, it is dedicated to another Academy member, Dr. E. H. Taylor, of the University of Kansas, and still other Academy members have contributed by their researches to the foundations upon which the book is based. Among the latter group is Dr. Charles E. Burt whose "Key to the Lizards of the United States and Canada", published in these *Transactions* (volume 38, 1935), Dr. Smith regards as "the most authentic summary of lizards that has appeared in recent years." In addition, the work and aid of Dr. Claude Hibbard, Dr. A. B. Leonard, Dr. Alexander Wetmore, Dr. Joseph Tihen, likewise Academy members, are all acknowledged by Dr. Smith.

The book, attractively printed and bound, is intended for the use of all naturalists, amateur as well as professional. Included in the book are 135 excellent plates, 136 figures in text and 41 maps showing the distribution of lizard species in the United States and Canada. Included also are state lists of species with literature references descriptive of the lizard residents in each state. Eight out of the fourteen literature references of species recorded in Kansas were published in these *Transactions.*

Dr. Smith, as stated in our last issue, is now a member of the faculty of the Texas A. and M. College, College Station, Texas.

Dr. L. J. Lyons of the biology department of the Fort Scott Junior College has accepted a position as head of the department of biology in Sioux Falls College, Sioux Falls, South Dakota. Dr. Lyons will assume his new duties beginning with the fall semester.

The University of Kansas sent a large group to the meetings of the American Society of Mammologists and the American Society of Ichthyologists and Herpetologists at Pittsburgh, Pa., during the week of April 15th. Those in the Kansas delegation included Messrs. E. C. Galbreath, E. R. Hall, C. W. Hibbard, D. F. Hoffmeister, E. W. Jameson, Joao Moojen, G. C. Rinker, H. W. Setzer, E. H. Taylor, and Ralph Taylor. Dr. E. R. Hall has been the president of the Society of Mammologists for the past year and Dr. C. W. Hibbard was re-elected to the board of directors of the Society. Dr. E. H. Taylor was re-elected vice-president of the Society of Ichthyologists and Herpetologists.

Recent publications of the State Geological Survey, University of Kansas, include:

Bulletin 64, Part 1, *Petrographic Comparison of Pliocene and Pleistocene Volcanic Ash from Western Kansas* by Ada Swineford and John C. Frye, 32 pages, 1 plate, 4 figures, April 15, 1946, 10 cents.

Subsurface Geologic Cross Section from Ford County to

Wallace County, Kansas, by Fanny Carter Edson, cross-section map 29½x34½ inches with explanatory legend, July, 1945, 25 cents.

Subsurface Geologic Cross Section from Ness County, Kansas, to Lincoln County, Colorado by John C. Maher, 13 pages and cross-section map 27½x43 inches with explanatory legend, 1946, 25 cents.

Copies of the above publications may be obtained by addressing the Geological Survey, University of Kansas, Lawrence, for mailing charges as indicated above.

Probably four major influences made this child: the home, where there was reading and considerable intelligent guidance which only later did he perceive, as he recalled certain attitudes of his parents; then came the barn, with its ancient lores and skills, its trapeze swinging from the rafter, its haymows full of somersets, forward and backward, where gangs of boys tried to reproduce circus gyrations; after the barn, the river—swimming, fishing, rowing in summer, and skating in winter; and the roaming through the timber, trapping quail and redbirds and mockingbirds and rabbits, and cutting stick horses in spring. Probably the stick horse has passed out of childhood. But this Willie, who developed his acquisitive faculty early, kept a stick-horse livery stable and was a stick-horse trader before he was seven. The woods also yielded walnuts for all the boys who would go after them, and a few hard hickory nuts and papaws after frost in autumn, and coffee beans and buckeyes, which had a certain commercial value in the primitive swapping commerce of childhood. The woods was a storehouse of all boys' treasures.

. . . .

Looking back now more than thirty years, I can shut my eyes and see that Bull Moose convention of 1912, see their eager faces—more than a thousand of them—upturned, smiling hopefully, with joy beaming out that came from hearts which believed in what they were doing; its importance, its righteousness.

It seemed to matter so very much, that convention of zealots, cleansed of self-interest and purged of cynicism. I have never seen before or since exactly that kind of a crowd. I impressed it on my memory because I felt as they felt—those upturned, happy faces.

And now they are dust, and all the visions they saw that day have dissolved. Their hopes, like shifting clouds, have blown away before the winds of circumstance. And I wonder if it did matter much. Or is there somewhere, in the stuff that holds humanity together, some force, some conservation of spiritual energy, that saves the core of every noble hope, and gathers all men's visions some day, some way, into the reality of progress?

I do not know. But I have seen the world move, under some, maybe mystic, influence, far enough to have the right to ask that question.—From *The Autobiography of William Allen White.**

*Reproduced through the kind permission of the publishers, The Macmillan Company, New York City.

Presidential Address

Kansas Academy of Science

1946

A Review of Kansas Ichthyology

JOHN BREUKELMAN
Head, Department of Biological Science,
Kansas State Teachers College of Emporia

INTRODUCTION*

This paper has three rather diverse but related purposes; first, to trace the development of scientific study of fishes in Kansas; second, to discuss some of the more important biological phases of fish conservation and management; third, to point out some of the more significant needs and possibilities for the future. These purposes are closely related because sound fish production and management (and good fishing) depend upon the application of established biological principles.

DR. JOHN BREUKELMAN

This is a review, not a treatise. It touches only the high spots, and some of those only lightly. As indicated above, one of its purposes is to call attention to needs for the future. It is hoped that some of those who read it may become interested in making collections or otherwise assist in bringing the status of Kansas ichthyology to the level of the other branches of zoology in the state and in developing a more constructive program of state fish conservation.

The author wishes to express his appreciation and thanks to the many individuals who have helped to make this review possible. Most of those who have helped in actual collection of specimens are named in the paper. Special thanks are due Carl L. Hubbs for identification of doubtful specimens and for much other help and encour-

---

Transactions Kansas Academy of Science, Vol. 49, No. 1, 1946.

*This paper omits the illustrations shown at the meeting, in the form of slides, includes considerable technical material not included in the address.

agement; Ted F. Andrews for assistance in checking records and making scale counts in subspecies comparisons; Mrs. Ted F. Andrews for the preparation of the bibliography, checking references to literature and proofreading the entire manuscript; Jean MacFarlane for making scale slides and measurements for growth studies; R. B. Downs for many miles of pleasant transportation; and not least, his wife Ruth Breukelman, for assistance ranging all the way from preparation of sandwiches for field parties to a variety of activities in the technical phases of the entire study.

It is becoming increasingly obvious that artificial propagation, stocking, legal limits and closed seasons, useful and necessary as they are, do not guarantee fish conservation or improvement of fishing. Indeed, any or all of them, applied under unsuitable conditions, may do more harm than good. For example, a lake already seriously overpopulated is heavily restocked, or fingerlings are planted in a type of water in which chances for survival are small.

In the management of a fish crop, as of a corn crop, there are right and wrong ways of procedure, even though the rights and wrongs are less well known for the fish than for the corn. The basis of right procedure is a continuing program of study and research. The essential facts are those concerning geographic and ecological distribution of the various species; living conditions of the lakes and streams; growth of fishes in various waters, especially artificial lakes; changes due to agriculture and to pollution; conditions favorable to artificial propagation and stocking. The special problems of Kansas result from its relatively small water area much of which is shallow, uncertain and variable.

It is scarcely necessary to mention that fisheries represent one of the valuable resources of the state, not equal to wheat or oil, to be sure, but of considerable proportions. Even if each fisherman who buys a license spent only $8.00 a year on his various fishing activities, a million-dollar "business" would be indicated. Of course the actual total, though it is not known accurately, is many times this amount.

The realization of the importance of scientific research in fish management is not new in Kansas. State Commissioner Gile stated in the *Fourth Biennial Report of the State Board of Agriculture* (1885):

"Before commencing the actual work of planting fish in the streams of the State, I found it necessary, in order to do effective, successful work in rehabilitating our streams with fish, to study carefully their nature and character in regard to temperature, volume and quality of water."

As early as 1883 the distribution of fishes selected on the basis of their probable survival in Kansas was an established practice. Commissioner Gile reported in 1885:

"... for the past two years I have, during the season for work, planted in the larger streams of the State, at points of my own selection, the following varieties of fish: Pike, wall-eyed pike, channel and blue catfish, black and striped bass, yellow, white and ring perch, and crappie. Each of these varieties are fine food-fish, and all but the crappie are gamy enough to please the most fastidious angler. This selection of fish for the streams of Kansas has been pronounced, by scientific ichthyologists, to have been the best that could have been made. Thus far they are a success, and in nearly every locality where they were planted a year ago some of each variety have been seen, and are reported to have made a rapid growth. I have no doubt but that all of these varieties will succeed, and rapidly develop in all the streams of the State. In order that they may do this, it is only necessary that the inhabitants along the streams do not interfere with them."

The subsequent history of fish conservation programs has not always justified the promise implied in these early statements. In the absence of a consistent plan and purpose, and with small or no appropriations, such success as has been attained was due largely to the persistent work of a few individuals. The general growth of the fish conservation program in Kansas has therefore resembled the tree-to-tree progress of an intermittently enthusiastic but undirected puppy.

REVIEW OF COLLECTIONS AND DISTRIBUTIONAL STUDIES

The study of fish distribution in Kansas was given a good start by the work of Snow, Wheeler, Cragin, Gilbert, Graham, Hay and others almost three quarters of a century ago, but the interest was not continued.

To be sure, considerable collecting, as well as some research in fish culture and propagation, has been done between that time and the present. However, most of the results have not been published, nor has there been follow-up work and coordination of effort such as has characterized, for example, the study of amphibia and reptiles of the state. No checklist of fishes of Kansas has been printed since the lists of Graham and Cragin which appeared in 1885. This is in strange contrast with the situation in regard to other vertebrates. Since 1900 we have had checklists or general papers on amphibia or reptiles or both by Branson (1904), Burt (1928, 1933), Smith (1934 and in press), Taylor (1929); birds by Bunker (1913), Long (1940) and Goodrich (1946); mammals by Allen (1940), Black (1937), Hibbard (1933, 1943), and Lantz (1904, 1906) as well as a large number of county or area lists of these groups. Since 1889 a scant half dozen papers, most of them very short, have appeared bearing directly on the distribution of fishes in the state. There is

no handbook of Kansas fishes, popular or technical, although more than a hundred species inhabit the state and more than 120,000 fishing licenses are sold annually. It seems strange that in a large state, with a variety of streams belonging to two great river systems, the scientific study of fishes has not received more attention.

The author published in 1940 an annotated list of fishes of northwestern Kansas. This is still the only sizable part of the state for which even a fair distributional picture can be given, although more actual material is available from certain other limited areas, especially in the vicinities of Manhattan, Lawrence, Ottawa and Emporia. Parts of the state that need particularly to be represented by further fish collections are: (1) most of the area southwest of a line from Ness City to Winfield; (2) the southern Flint Hills; (3) the glacial drift area, i.e., the part of the state north of the Wakarusa river and east of the Blue; (4) the area including the lower reaches of the Republican, Solomon, Saline and Smoky Hill rivers; (5) the Kansas river and that portion of the Missouri bordering on Kansas.

Through the 1850's and 1860's there were casual references to Kansas fishes and listing of certain species; among these, Abbott in 1861 and Gill in 1864 described new species from the area. The first general paper, however, was that of Snow (1875) who published a list, with observations on life habits and ecology, of the fishes of the Kansas river as observed at Lawrence. Wheeler presented in 1878 a similar list from the Marais des Cygnes at Ottawa.

During the years 1884 to 1889 the Natural History Department of Washburn College undertook a biological survey of the state. Results of the investigations were printed in the *Bulletin of the Washburn College Laboratory of Natural History,* published from 1884 to 1889. Collections from various parts of Kansas, as well as taxonomic and other studies, were reported by Cragin (1885), Gilbert (1884, 1885, 1886, 1889) and Evermann and Fordice (1885). These collections were destroyed about twenty-five years ago by a fire which gutted the building in which they were housed.

Graham (1885) published a list of the fishes in the museum of Kansas State College at Manhattan, and also a checklist (1885) of the fishes of Kansas, based both on his own collection and on material reported by others. Many of the Graham specimens are still in the Kansas State College Museum.

Hay (1887) reported a list of fishes taken from six localities

on the Republican, Saline, Solomon and Smoky Hill rivers. Many of the specimens are in the National Museum.

The biological survey of the University of Kansas made a collection of fishes, mostly during the years 1910 to 1912. Expeditions under the direction of R. D. Lindsey collected some 2500 specimens including almost 60 species. From time to time various other collections were added. The collection was checked and cataloged by the author of this paper and a list published in the *Transactions of the Kansas Academy of Science* in 1940.

A rather extensive collection was made during the years 1924 to 1929 by Minna E. Jewell, who was then an instructor in zoology at Kansas State College. This material, collected from widely scattered localities in western and central Kansas, is now in the Museum of Zoology of the University of Michigan, where it has been checked by Carl L. Hubbs, C. W. Hibbard and the author. The Michigan museum has considerable material from Kansas, aside from the Jewell collection, all of which has been checked recently by Hubbs and the author.

A. J. Cheatum submitted at Kansas State College in 1926 a master's thesis on the distribution of fishes in Kansas. It is largely a compilation, but includes some records not listed elsewhere.

Hall (1934) published an ecological study of the fishes in Mineral Lake, a small body of water in Crawford County. The specimens are in the museum of Kansas State Teachers College of Pittsburg, with some duplicates in Michigan.

Hoyle (1934) included some species of fishes in his discussion of faunal collecting in localities near Wichita and Winfield.

In July, 1938, a party consisting of Paul B. Allen, Ethan Gill, Loren W. Mentzer and the author spent a week seining various stations in the Republican, Saline, Smoky Hill, Solomon, and their tributaries. Some 1,600 specimens, representing 20 different species, were taken. In July, 1940, a party consisting of Theodore Downs, Gerald Hartman, Loren W. Mentzer and the author seined localities in the southwestern part of the state, in the Ninnescah, Chikaskia, Medicine Lodge, Cimarron, Arkansas and their tributories. About 3,000 specimens, representing 41 different species, were taken. Most of the specimens resulting from these two expeditions* are in the museum of the State Teachers College at Emporia or in the Museum of Zoology, University of Michigan. The author (1940) has published a list of the fishes of northwestern Kansas.

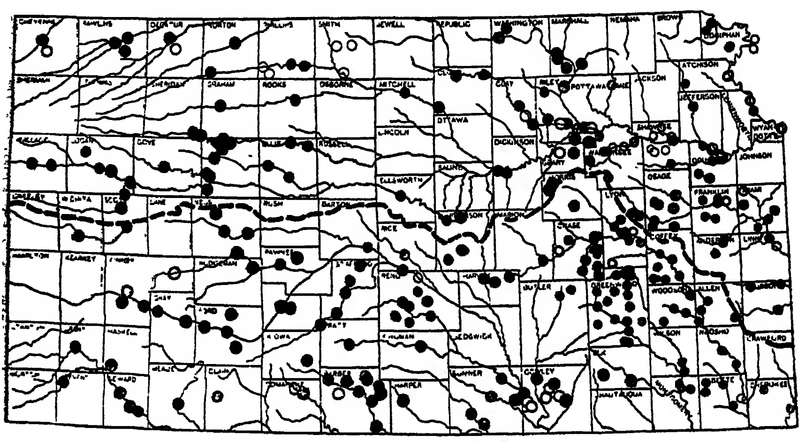
*Both were financed in part by research grants from the Kansas Academy of Science.

Jennings (1942) published a revised list of the fishes in the museum of Kansas State College; some of the material was collected in the 1880's by Graham and others, but much material has been added recently.

Collections ranging in size from a dozen to several thousand specimens have been sent to Emporia by various students of the author. Their names and the localities involved follow:

Paul B. Allen—tributaries of the Neosho in Coffey County;
E. L. Kirkpatrick—the Verdigris and its tributaries, the Fall and its tributaries in Greenwood County;
Ethan M. Gill—Salt creek near Osage City;
John Sarracino—Verdigris river at Neodesha;
Ralph I. Imler—Solomon river near Stockton;
Glen Love—Ninnescah river near Partridge;
Hugh Hanson—Walnut creek near Ness City;
Loren W. Mentzer—Medicine Lodge river and its tributaries near Medicine Lodge, Arkansas river and its tributaries near Dodge City and Ford;
Roberts E. Buchanan—Saline river and Big Creek near Wakeeney;
Allen Downs—Smoky Hill river in Wallace County.

The collection localities that could be determined with reasonable certainty, either from specimen labels or from literature records, are shown on the accompanying map.



DISTRIBUTION OF KANSAS FISHES. Solid circles indicate specimens; open circles indicate records from literature.

Many problems of distribution and taxonomy remain. For purposes of this paper, a few examples will suffice. An interesting case is the fathead minnow, *Pimephales promelas.* Practically all specimens thus far collected (and this is one of the most common minnows in Kansas) are, according to the best descriptions available, intergrades. A few are very near the typical *promelas,* with

a very short lateral line and oblique mouth. Some may be considered as typical *confertus,* with the complete lateral line and the horizontal mouth, but the geographical distribution of the typical, or near typical, forms is very confusing. When an area as large as the entire state of Kansas is populated with intergrades, the subspecific descriptions need critical examination.

A single specimen of the flathead chub *Platygobio gracilis* from Mulberry creek, near Ford, Kansas, is about half way between *Platygobio gracilis communis,* the regular Missouri river form, and the forms from the upper Arkansas and the far west; a series of specimens from this area is necessary to determine the status of the Kansas representatives of the species.

Large numbers of *Notropis zonatus pilsbryi,* a common Ozarks minnow, were taken in 1938 from the small creek that emerges from Jack's Spring, near Matfield Green. This is the only locality in Kansas, thus far, although most of the area to the southeast has been seined more or less thoroughly. It seems unlikely that this form is thus restricted. More seining of the spring-fed creeks of eastern and southern Kansas is necessary to solve this distributional problem.

STATE AGENCIES FOR FISH CONSERVATION

The first state law on the subject of fish conservation, enacted in 1877, provided for the appointment of a Commissioner of Fisheries, who should determine ways and means for making Kansas fishing waters more productive. Almost every subsequent legislature has made some addition or change.

In the *First Biennial Report of the Commissioner of Fisheries,* D. B. Long reported:

> "The large territory comprising the state of Kansas, larger than all the New England States, with its long streams and numerous branches, gives to the fish culturist a vast field for labor. While I have endeavored to make my investigations as thorough as possible, and to gather such facts as will be of interest and use to the State, the time allowed has been far too short to meet all the requirements and demands made upon the Commissioner.
>
> "It must be remembered that, in a branch of industry new to the people, and having the importance of this new enterprise, nothing can be done hastily. It requires time, patience, perseverance and money—with which there is no doubt of ultimate success in stocking our streams with a better variety of fish. As so little is known of the labor and workings of this important branch of farming that is attracting the attention of the civilized world, I deem it not improper to give a brief history in this first report."

The *First Biennial Report* indicated expenses of $330.55, leaving $169.45 of the original $500 appropriation unexpended.

In this report Long called attention to the necessity of fish-ways and described how these might be constructed. He included Snow's report (1875) on the native fishes found at Lawrence and discussed

the introduction of shad and California salmon into Kansas waters. On June 5th, 1877, 100,000 young shad arrived in Topeka for distribution, and on October 10, 1877, the same number of California salmon eggs, shipped from California to Chicago in a refrigerator car and from Chicago to Ellsworth by express, arrived "in very good condition." The shad were all placed, without the authority of the Commissioner, in the Kansas river at Topeka; the salmon eggs were accidentally lost by a sudden rise of the river which washed away the hatching boxes. In 1879, 160,000 shad were distributed in various places in the state also 60,000 California salmon and 30,000 lake trout. In 1879-1880, 20,000 salmon eggs were hatched and the young salmon distributed in various localities. The following year 100,000 more lake trout were distributed in streams along the Central Branch Railroad, The Atchison, Topeka and Santa Fe, and the Kansas Pacific.

The *Second Biennial Report* includes a letter which will be of interest to the older members of the Academy:

"Cottonwood Ranch, Ellsworth Co., Kans., Nov. 2, 1880. D. B. Long, Esq., Fish Commissioner: Dear Sir—As you will doubtless be glad to hear good reports of the results of your labor as Fish Commissioner, I will give you a fact that I noticed this summer. While fishing in the Smoky Hill river, a mile above your place, I caught a number of small salmon trout, the same as found in California; they were about three inches long. I caught them from a school of a hundred or more. This promises well for the enterprise you are engaged in. Wishing you continued success, I am, very truly, yours, /s/ Chas. H. Sternberg."

In the *Second Biennial Report* (1879), Long recommended that for a period of years all fishing except with a hook, line and rod be made illegal, that all persons erecting dams be supplied with plans for construction of fishways, that $2,000 be appropriated for erecting a fish hatchery, that one member of the commission be a full time superintendent, and that $3,000 be appropriated for expenses for fish collecting and experimental work. (The appropriation recommendations were not followed. The appropriation for the subsequent biennium was again $500 a year.)

In the *Third Biennial Report* (1881), Commissioner Long praised the carp as a desirable fish to be raised in quantity and described the construction of carp ponds. The distribution of carp, obtained from St. Louis, was started in 1880 with an initial shipment of 160 specimens. As late as 1890 the Biennial Reports still referred to the carp in favorable terms. The first critical report was that of Commissioner Sadler in 1896, but not until 1902 was there a recommendation that this species be destroyed. Salmon and trout were planted throughout the 1880's. Commissioner John Brumbaugh

mentioned in the *Seventh Biennial Report* (1891) that, "Salmon have also been put into our streams, but it is a question needing further time for a satisfactory solution as to whether they will thrive and propagate in our waters. They are heard from occasionally as having grown to maturity, and again as having been seined out and taken for food when weighing only about a pound each."

It is common knowledge that the German carp has been highly successful in Kansas waters and is at the present time one of the most widespread species. The attempts to establish trout and salmon were, however, complete failures. Apparently no trout or salmon have been taken in the state except within a few months after their planting; apparently the net result was confusion of fishermen who had become accustomed to catfish.

In 1905 the fish and game programs were united and the office of State Fish and Game Warden was established. D. W. Travis, who started construction of the first state fish hatchery, was the first to hold this office. His duties included the management of the fish hatchery and the distribution of fish, as well as the enforcement of the protection laws.

In 1927 all fish and games policies were placed in the hands of the reorganized Forestry, Fish and Game Commission and in 1935 the Commission was once more reorganized to its present status. The history of the changes in policy and administrative machinery has been set forth in detail in a fully documented paper by Stene (1945).

The biological phases of the fisheries activities of the Commission have been reported in various *Bulletins, Biennial Reports,* and other Commission publications. Much of this material, especially as it bears on wild life conservation in general, has been summarized by Mentzer (1941).

The first major contribution on pond fish culture in Kansas was a 208 page bulletin by L. L. Dyche (1914) who in 1909 was lent by the University of Kansas to the State Fish and Game Department, and remained as fish and game warden until his death in 1915. The Pratt Hatchery, at the time the largest of its kind, was built during his administration. Dyche's description of pond conditions, spawning habits and life history of the bass, crappie, sunfishes, bullheads and other common species, and his general discussion of the conservation in relation to soil fertility were written largely on the basis of his own observation. His publications were widely circulated

through the state but unfortunately were not followed by others of equally comprehensive and scientific nature.

In 1926 a cooperative agreement was made with Kansas State College which made a part-time biologist available for the problems of fish production. Minna E. Jewell, a member of the zoology staff, assigned her research assistant, Edward Schneberger, to the Pratt Hatchery during the summer of 1927. In 1928 they presented in a bulletin of the Commission their "Reports of Experiments Conducted by the Zoology Department of the Kansas State Agricultural College at the Kansas State Fish Hatchery," in which they discussed in some detail the effect of plankton, vegetation, turbidity, and other factors on fish production. The same year Schneberger reported on experimental work in the feeding of channel catfish in the Hatchery. Furthermore, in collaboration with Seth Way, fish culturist at the Pratt Hatchery, considerable research was done on the breeding habits of the catfish. The results were not published at the time, but many valuable facts were discovered, leading eventually to a regular program of channel catfish propagation. This work, which has been under the constant direction of Way and his assistants has been outstandingly successful, and was described in part in the *Second Biennial Report of the Forestry, Fish and Game Department,* 1928, and has received some mention in later publications.

Warden J. B. Doze stated in 1928 that the cooperative agreement with the Kansas State College was being continued but subsequent commission literature makes no mention of it.

Considerable work has been done since then, especially in the raising of Daphnia for fish food and in the control of parasites. But staff time and facilities have not been available for complete and systematic studies. Nor, (with the exception of brief items in the *Biennial Reports* and in the public press), have the results been published.

Beside the *Bulletins* and *Biennial Reports* the Commission publishes (temporarily suspended during the war) a popular magazine, *Kansas Fish and Game.* This eight-page journal is sent free of charge to any citizen of Kansas who requests it, the current mailing list including about 3,000 names. From time to time it has carried descriptions, frequently illustrated with photographs or drawings, of various species of Kansas fishes. It has been helpful, in the absence of any type of popular handbook, in acquainting the public with Kansas fish species and fisheries resources. It has done constructive work in keeping its readers informed concerning changes in fishing

seasons and laws and has included a great deal of information about current fishing conditions in Kansas lakes and streams.

This magazine has also perpetuated some outstanding errors. For example, it has listed among the common Kansas fishes the brown bullhead, *Ameiurus nebulosus,* which is rarely if ever found here. And it has at times omitted the yellow bullhead, *Ameiurus natalis,* and at other times the black bullhead, *Ameiurus melas,* both of which are very common. Again, it has listed and illustrated as a common Kansas fish the small-mouthed bass, *Micropterus dolemieu,* which if present at all is extremely rare, instead of listing the spotted or Kentucky bass, *Micropterus punctulatus,* which occurs generally throughout the state. Such errors are inevitable in the present Kansas situation and are to be charged not to carelessness on the part of *Kansas Fish and Game* but to a lack of fundamental research on which accurate popular writings could be based.

COMMERCIAL FISHING

It is not generally known among Kansans that the state has a small amount of commercial fishing, restricted to the lower Neosho, the Kansas, and that part of the Missouri bordering on Kansas. The latest detailed report of the fishery industries of the United States (1932), issued from time to time by the Bureau of Fisheries, listed a total of 123 nets of various types, 18 motor boats and 123 other types of boats in operation. The catch was reported as follows: buffalo fish, carp, catfish and bullheads, quillback or "American carp," sturgeon, and shovelnose, a total of about 140,000 pounds valued at about $14,000. Alexander (1946) reported that private customers take about one-half of the fisherman's catch and that the remainder go to wholesalers. The total business of river fishermen in the Kansas City area on "good-days" runs from $200 to $300. He reported that customers prefer catfish first of all, then spoonbill and sturgeon, then blue and white suckers, with carp and buffalo at the bottom of the list. He further mentioned in a personal letter to the author that freshwater herring, also known as silver herring, and jack salmon were being caught in the Kansas City area.

According to the *Tenth Biennial Report of the Forestry, Fish and Game Commission,* (1944):

"Commercial fishing is controlled by strictly enforced regulations which provide for a closed season on certain species of fish, and for the issuance of a special license for the use of specified seines and equipment, the use of which is prohibited elsewhere in the state. The regulations also restrict the type of fish that may be taken and sold. The types of fish covered by the regulations are those commonly designated as rough fish and not ordinarily sought by sportsmen. Many Kansans are engaged in commercial fishing

and are profitably disposing of their catches in the larger cities of Kansas and Missouri."

GROWTH STUDIES

Both the advance of the science of ichthyology in Kansas and the improvement of fishing in the lakes of the state demand a continuing program of research in fish growth. Such research, correlated with population studies, is the basis of much of the progress in fish culture.

During the course of the past half century the scale method of determining the age of a fish has been well established. A scale-fish carries with it, recorded on each of its scales, an autobiographical record of seasonal growth, spawning, abnormal interruption of growth, loss of scales and their regeneration, and several other features of its life history. Many other organisms, both plant and animal produce such records, e.g. tree rings. But few autobiographies are as detailed as those of the fish, or produced in as many copies. A golden shiner has more than two thousand scales.

Briefly, the scales are arranged somewhat like shingles on a roof, the posterior margins being exposed and the anterior portion being covered by the scales in front. As the fish increases in size, the number of scales remains constant, the length of the scales increasing approximately in proportion to the increase in body length. Growth is interrupted each winter, leaving a record similar to the familiar tree rings. The details of the method, with a critical discussion of its difficulties and limitations, have been set forth by Van Oosten (1928) and many others, and are not necessary to relate here.

Not only do the growth rings reveal the age of the fish, but they also give a fairly accurate indication of its approximate size at any previous age, since scale length (1) and body length (L) remain in proportion, i.e., the L/1 ratio remains constant. Actually, the problem is not quite this simple, there being several complicating factors. For example, there are in common use several different measurements of length, variously known as total length, standard length (measured in at least eight different ways), fork length (median length), natural tip length, and extreme tip length, not to mention the "extreme length plus" in common use among story-telling fishermen. The advantages and relative accuracies of the various measurements have recently been summarized by Ricker and Merriman (1945). Furthermore, since the scales overlap, they do not necessarily grow in exact proportion to growth in body length, that is, the percentages of overlap may change; thus there are various modi-

fications and corrections. Although these have to be worked out for each species, they are usually comparable for closely related forms. Accurate figures are available for several of the species that are commonly used for growth studies, for example, the basses, sunfishes, and golden shiners.

Fishes vary in their usefulness in growth studies. Among common Kansas species that have often been used in such research in other states are the basses, crappies, sunfishes and golden shiners. The last named is a common forage fish, is highly sensitive to environmental conditions, and has scales with markings that are relatively easy to decipher. The gizzard shad is another useful forage fish, also highly sensitive, but with scales that are much harder to "read."

The author has measured only one small series (32 specimens) of golden shiners, almost all collected at a single station in Lyon County State Lake. The measurements indicate that growth is about average, as compared with a large series from Michigan measured by Cooper (1936). The Michigan specimens were from natural lakes and from an area with a shorter growing season than that of Lyon county. It is difficult without further studies to know how much to allow for differences in growing season.

ARTIFICIAL PONDS AND LAKES

These constitute practically all of the water areas of Kansas, exclusive of the streams. The state has almost no natural water to which the term lake can properly be applied.

The artificial lakes are the outstanding development of the period following the 1927 reorganization of the Fish and Game Department. Five state parks, built around artificial lakes as central features, were actually under construction in 1928 and several more were started the next year. When lake building activities were stopped because of the war, the Commission had under its supervision more than twenty such parks. No doubt the near future will see further enlargement of the water areas of Kansas, thus carrying forward the plans of Warden Doze, who in 1924 advocated this means of increasing the state's supply of fish.

To date almost all research on the growth and population of fishes has been done in natural waters. Among the outstanding exceptions are the studies of Ricker (1942) and Johnson (1945) in Indiana, Bennet (1943) in Illinois, Swingle and Smith (1940-1941) in Alabama.

The last decade has witnessed the growth of a considerable body

of literature bearing on the management and improvement of artificial ponds and lakes. Some of the papers, like those by Swingle and Smith (1941) deal with specific problems; others like those by Clark (1936) and Allan and Davis (1941) deal with pond problems in general. Viosca's book on pond fish culture (1937) and Hubbs and Eschmeyer's book (1938) or improvement of lakes and fishing are both of general application. Some of the more recent papers like those of Davison (1943) and Bennett (1943), both published by the United States Department of Agriculture, deal with pond fish production from the standpoint of fish as food. Bennett says that managed ponds on American farms have a potential production of one hundred million pounds of fish annually.

The Kansas lakes were for the most part constructed without much attention to the necessities and possibilities for aquatic life. Most of them have entirely inadequate spawning areas, and some seem quite lacking in the fundamentals of a natural food supply.

No extensive researches have been conducted in Kansas, but casual and scattered observation indicates that several of the lakes are seriously overpopulated, in terms of space, food supply, spawning areas, and other necessities of normal aquatic life. In a few cases thorough seining has shown that there was a serious lack of forage minnows, even though the algae and other lower plants seemed to be sufficient for a basis of a good food supply.

Conditions favorable to successful natural reproduction of lake fishes, as outlined by Hubbs and Eschmeyer, include:

(1) A water level stable enough to avoid drying the eggs or fry, or subjecting them to either abnormally shallow or deep waters.

(2) A water level which covers the spawning grounds to a proper depth, whether these grounds be a gravel bar, a bulrush patch or a marsh.

(3) Favorable chemical conditions in the water covering the spawning beds, particularly a high content of dissolved oxygen.

(4) Relatively constant temperatures, not rising high enough to harm the eggs and not dropping low enough to kill the spawn or to drive the fish off their beds before the spawning or the guarding of the eggs is completed.

(5) Temperatures low enough or high enough, depending on the species, for the fish to spawn normally. Many northern lakes seldom become warm enough (about 68° F.) on the shoals for bluegills to spawn.

(6) Waters relatively free from smothering silt, whether caused by waves and currents, by motor boats, or by wading. A coating of silt is harmful to fish eggs.

(7) Spawning beds relatively free from disturbance, by motorboats or bathers. Within 5 minutes after the guarding adult fish is driven off, every egg or fry on a bluegill redd may be eaten by minnows or other predators.

(8) Protection from fishing during at least the height of the spawning season. The dates of spawning vary with the species, with the locality and with the season, and should be independently determined for each part of the state.

(9) A sufficient area of the proper bottom material for the depositing of the eggs, at suitable depths and in places adequately protected from wave action. Satisfactory nesting material, which varies according to the habits and needs of the species, as indicated on Pp. 98-108 should serve to support the eggs above and free from bottom silt."

Not many of the Kansas artificial lakes can make a high grade on this test.

It is well known among fisheries biologists that artificial lakes may go through a period of extremely good fishing for a few years, usually about three to six years after their completion, and then drop off to a stable level of poor fishing, as compared with natural lakes of similar size and depth. The ecological basis of this phenomenon has not been studied adequately, but Kansas has had many illustrations of it. It is highly probable that careful ecological studies of new artificial lakes would yield information that would help to maintain a better permanent population of fish and other aquatic life.

ECOLOGICAL CHANGES AND POLLUTION

Since the days when the Neosho and other similar streams of eastern Kansas were relatively clear except at flood times, the plow and the woodman's axe have brought about many ecological changes in the habitats of Kansas fishes. *The River* has been so widely publicized that it is unnecessary to add anything here.

The collections of the early years of the history of the state offer an opportunity to trace the effects of some of these changes. For example, Hay (1887) reported "numerous large specimens" of the horny-headed chub, *Nocomis biguttatus* (Kirtland), from the Saline river near Wakeeney and also reported them from the Smoky Hill river at Wallace. Careful seining of Hay's localities in 1938 and 1939 failed to reveal a single specimen, and questioning of local fishermen indicated that if present in the area now the species is extremely rare. In view of the fact that large specimens of this species are not apt to be misidentified, a change in the fauna of the area seems to be indicated. This is the type of change that might be expected in a stream that has changed from a generally clear to a frequently muddy one. In the meantime, other species than can live successfully in muddy water, have apparently extended their range over much more of the state than indicated by early reports.

Pollution of the fishing waters of the state has been a serious problem for many years. As early as 1907 the legislature enacted a law giving the State Board of Health authority to require sewage treatment where the failure to provide treatment would be detrimental to public health. This authority was extended in 1927 to

cover investigations of stream pollution found to be detrimental to aquatic life; however, no funds were made available for investigational studies until 1933.

In 1920 Warden Clapp said:

"Many of the finest streams of our state are now destitute of fish on account of oil and salt pollution. The Walnut river, once as fine a bass stream as could be found anywhere, and a beautiful stream, too, is now a murky oil run, and does not contain a single fish so far as I know. The Fall and Verdigris rivers are practically ruined. Both the Caney rivers are affected, as is also the Neosho. Even the famous Cottonwood is now in the oil belt and may soon be ruined for fishing. Many other streams are affected, and when you remember that most all the little creeks flowing into these rivers are in similar plight, it is a bad condition indeed. This is not all. Some of the best streams in our state touch the zinc belt and are badly impregnated with mineral. Some of our railroads, using oil-burning engines, are simply dumping the refuse, thus allowing it to find its way into the streams, where it kills thousands of fish. This condition could have been avoided, and even now should be remedied. It will be years before the Walnut river will contain fish again, even though another drop of oil never reaches it. But nature is a great solvent, and in time will repair the havoc we have wrought. It should be given a chance."

Four years later Doze commented as follows: "Correction of stream pollution will not come in a day. This problem will require years of thought and work. The Fish and Game Department has made a number of surveys of polluted streams, locating causes and pointing out these causes to those responsible. But the legal machinery is slow to turn and difficult to get started toward corrective measures. This subject is sufficiently large and important to require the undivided attention of a corps of experts."

Obviously any effective plan will have to be developed by general cooperation involving cities, industries, governmental agencies, the sportsmen and the general public. Guy D. Josserand, Director of the Forestry, Fish and Game Commission, reported after a conference between representatives of the oil industry and the State Board of Health, held in Wichita in May, 1940, "Successive conferences are to be held with the refineries and producers relative to this problem in the Walnut Valley. Three problems present themselves to be solved: First, can the pollution be abated? Second, will the cost be commensurate with the benefits derived? Third, are all those affected willing to do all in their power to correct the situation? We believe the third question is quite easily solved. The other two are not impossible, but will require a great deal of study." In recent years general cooperation has developed a much more wholesome attitude toward pollution problems and a strong public sentiment in favor of enforcement of existing laws. While the problems are far from being completely solved the general situation is decidedly favorable as com-

pared with the last quarter century. The *Tenth Biennial Report* (1944) states that the commission employees, working in close harmony with the Board of Health, kept Kansas waters unpolluted for public health and free for fish life.

NEEDS AND POSSIBILITIES

Kansas needs many more lakes and ponds, both large and small. Some of them will be primarily for flood control; the variable level of these may preclude their best usefulness as fishing lakes. However, the very fact that floods are kept under control improves the conditions for fishing in the controlled streams.

Important for both flood control and wildlife conservation are the so-called "low water dams" and farm ponds; these can be built in large numbers at relatively small cost.

Some research areas need to be set aside for long-time studies, preferably in the well established state lakes, so that the observations made in the research areas can be correlated with the fishing results in the same lake. Setting aside such areas need not interfere with fishing or other recreational uses of the lake. The areas most desirable from the standpoint of research are usually not the best for fishing and swimming. Ecological observations of new lakes should not be neglected, especially in those lakes where fishing is reported exceptionally good or poor, or in other ways unusual.

A continuous survey of a large number of lakes should be undertaken. This can be done with a relatively small staff. Obviously, an exhaustive study cannot be made in a few days, but the essential features can be determined. The techniques for stream and lake surveys have been worked out in detail and considerable literature is available. The general methods of conducting a survey and recording findings have been summarized by Davis (1938). Of course, local adaptations must be made, but these deal for the most part with details, since the basic methods and equipment are relatively uniform.

Intensive growth studies must be made in a few selected lakes; these will form a part of the basis for the remedial measures to be applied to such lakes as do not support a good crop of fish for the angler.

Many of the lakes of the state need fertilization, planting, establishment of spawning areas, shelters, and other improvements; such improvements should be made on the basis of a thorough knowledge of what is going on in each lake, and not in response to a demand for increased stocks for fingerlings.

Not a few students of conservation policies doubt that effective progress can be made by an agency that derives its financial support entirely from hunting and fishing license fees, since this gives a certain interest group the feeling that it "owns" the department. It is contended that a legislative appropriation would indicate more general interest in wildlife conservation, and that appropriated funds would be less subject to manipulation by pressure groups. The problem of finances lies beyond the scope of this paper; however, it seems evident from what has been accomplished that sound conservation can easily be achieved under the present framework. It seems equally evident that it can be achieved only on the basis of sound application of established biological principles.

LITERATURE CITED

ABBOTT, C. C., "Descriptions of Two New Species of Pimelodus from Kansas," Proc. Acad. Nat. Sci. Phil., :568-569, 1861.

ALEXANDER, JOHN, "Catch Big Fish in Shadow of Kansas City Skyscrapers," The Kansas City Star, Mar. 10, 1946.

ALLAN, PHILIP F. and CECIL N. DAVIS, "Ponds for Wildlife," Farmers' Bulletin No. 1879, U.S.D.A., 45 pp., 1941.

ALLEN, PAUL B., "Kansas Mammals," Kan. St. Tchr. Coll. of Emporia, Bull. of Inf., Vol. 20, No. 5, 62 pp., 1940.

BENNETT, GEORGE W., "Management of Small Artificial Lakes," Bull. of the Ill. Nat. Hist. Sur., 22:355-376, 1943.

BLACK, J. D., "Mammals of Kansas," Kan. St. Bd. of Agr., Thirtieth Biennial Report, 35:116-217, 1937.

BRANSON, EDWIN B., "Snakes of Kansas," Kan. Univ. Sci. Bull., 2(13)353-430, 1904.

BREUKELMAN, JOHN, "The Fishes of Northwestern Kansas," Tran. Kan. Acad. Sci., 43:367-376, 1940.

——— "A Collection of Kansas Fishes in the State University Museum," Ibid., 377-385.

BRUMBAUGH, JOHN M., Seventh Biennial Report of the Commissioner of Fishes, in Public Documents, Kansas, Vol. II (1889-90), 1890.

BUNKER, C. D., "The Birds of Kansas," Kan. Univ. Sci. Bull., 7(5)137-158, 1913.

BURT, CHARLES E., "Key to Kansas Lizards," printed privately for the author by the Bristow (Nebr.) Enterprise Press, 2 pp., 1928.

——— "Some Distributional and Ecological Records of Kansas Reptiles," Tran. Kan. Acad. of Sci., 36:186-208, 1933.

CHEATUM, A. J., "Distribution of Fish in Kansas," unpublished thesis, Kansas State Agricultural College, Manhattan, 1926.

CLAPP, ALVA, "Stream Pollution." Bull. No. 6, Kan. Fish and Game Dept., p. 33, 1920.

CLARK, MARION W., "Farm Ponds in Missouri," Univ. of Mo. Col. of Agr., Extension Service, Circular No. 351, 11 pp., 1936.

COOPER, GERALD P., "Age and Growth of the Golden Shiner (*Notemigonus Crysoleucos Auratus*) and Its Suitability for Propagation," Mich. Acad. of Sci., Arts, and Let., 21:587-597, 1936.

CRAGIN, F. W., "Note on the Chestnut Lamprey," Bull. Wash. Col. Lab. Nat. Hist., 1(3):99-100, 1885.

——— "Preliminary List of Kansas Fishes," Ibid., 105-111, 1885.

DAVIS, H. S., "Instructions for Conducting Stream and Lake Surveys, U. S. Dept. of Comm., Fishery Circular No. 26, 53 pp., 1938.

DAVISON, VERNE E., "Fish for Food From Farm Ponds," Farmers' Bulletin No. 1938, U.S.D.A., 21 pp., 1943.

DOZE, J. B., "Stream Pollution," Fifth Bien. Rep. Kan. Fish and Game Dept., p. 31, 1924.

DYCHE, L. L., "Ponds, Pond Fish, and Pond Fish Culture," State Dep. of Fish and Game, Bull. No. 1, pp. 1-208, 1914.

EVERMANN, BARTON W. and MORTON W. FORDICE, "List of Fishes Collected in Harvey and Cowley Counties Kansas," Bull. Wash. Lab. Nat. Hist., 1:184-186, 1884.

FIEDLER, R. H., Fisheries Industries of the United States, U.S. Dept. Comm., Bureau of Fisheries, 449 pp., 1932.

GILBERT, CHARLES H., "Notes on the Fishes of Kansas," Bull. Wash. Lab. Nat. Hist., 1:10-16, Sept. 1884.

——— "Second Series of Notes on the Fishes of Kansas," Ibid., 1(3):97-99, 1885.

——— "Third Series of Notes on Kansas Fishes," Ibid., 1:207, 1886.

——— "Fourth Series of Notes on the Fishes of Kansas," Ibid., 2:38, 1889.

GILE, W. S., "Fish Culture," Kan. State Bd. Agr., Fourth Bien. Rep., 9:643-644, 1884.

GILL, THEODORE, "*Percopsis hammondi* Gill, from Kansas," Proc. Acad. Sci. Phil., 16:151, 1864.

GOODRICH, ARTHUR L., Birds in Kansas, Kan. St. Bd. of Agr., 340 pp., 1946.

GRAHAM, I. D., "A Preliminary List of Kansas Fishes," Tran. Kan. Acad. Sci., 9:69-78, 1885.

——— "Some Kansas Fishes Now in the College Museum," from a paper before the Scientific Club. The Kansas Industrialist, 10(30), 1885.

HALL, HARRY H., "An Ecological Study of the Fishes of Mineral Lake, Kansas," Tran. Kans. Acad. Sci., 37:225-229, 1934.

HAY, OLIVER PERRY, "A Contribution to the Knowledge of the Fishes of Kansas," Proc. U. S. Nat. Mus., 10:242-253, 1887.

HIBBARD, CLAUDE, "A Revised Checklist of Kansas Mammals," Tran. Kan. Acad. Sci., 36:230, 1933.

——— "A Checklist of Kansas Mammals, 1943," Ibid., 47:61-88, 1944.

HOYLE, WILLIAM LUTHER, "Notes on Faunal Collecting in Kansas," Tran. Kan. Acad. Sci., 39:285, 1936.

HUBBS, CARL L., and R. W. ESCHMEYER, The Improvement of Lakes for Fishing, Mich. Dept. of Conservation, 229 pp., 1938.

JENNINGS, DOLF, "Kansas Fish in the Kansas State College Museum at Manhattan," Tran. Kan. Acad. Sci., 45:363-366, 1942.

JOHNSON, WENDELL L., "Age and Growth of the Black and White Crappies of Greenwood Lake," Investigations of Indiana Lakes and Streams, 2:297-324, 1945.

JOSSERAND, GUY D., "Pollution," Kansas Fish and Game, II(6):9, 1940.

LANTZ, D. E., "A List of Kansas Mammals," Tran. Kan. Acad. Sci., 19:171-178, 1903,1904.

——— "Revised List," Ibid., 20(2):214-210, 1906.

LONG, D. B., First Biennial Report of the Commissioner of Fisheries, Public Documents of Kansas, 1877-1878, 1879.

——— Second Biennial Report of the State Fish Commissioner, Public Documents of Kansas, 1879-1880, 1881.

——— "Fish Culture," Third Bien. Rep. St. Bd. of Agr., (1881, 1882), pp. 659-662., 1883.

LONG, W. S., "Check-list of Kansas Birds," Tran. Kan. Acad. Sci., 43:433-456, 1940.

MENTZER, LOREN W., "Wildlife Conservation," Kan. St. Tchr. Col. of Emp., Bull. of Inf., Vol. 21, No. 6, 63 pp., 1941

RICKER, WILLIAM E., "Fish Populations of Two Artificial Lakes," Investigations of Indiana Lakes and Streams, 2(13):256-265, 1942.

RICKER, WILLIAM E., and DANIEL MERRIMAN, "On the Methods of Measuring Fish," Copeia, No. 4:183-250, 1945.

SCHNEBERGER, EDWARD, "Feeding Spotted Channel Catfish (*Ictoluris punctatus*) at the Kansas State Fish Hatchery at Pratt, Kansas," Kansas Fish and Game Department, pp. 63-66, 1928.

SCHNEBERGER, EDWARD, and MINA E. JEWELL, "Factors Affecting Pond Fish Production," Bull. No. 9, Kan. For., Fish and Game Comm., 14 pp., 1928.

SMITH, HOBART M., "The Amphibians of Kansas," Am. Mid. Nat., 15(4): 377-528, 1934.

SNOW, F. H., "Fishes of the Kansas River as Observed at Lawrence," Fourth Agricultural Report and Census, pp. 139-141, 1875.

STENE, EDWIN O., "The Development of Kansas Wildlife Conservation Policies," Tran. Kan. Acad. Sci., 47(3):289-324, 1945.

SWINGLE, H. S. and E. V. SMITH, "Experiments on the Stocking of Fish Ponds," Tran. Fifth N. A. Wildl. Conf., pp. 267-276, 1940.

——— "The Management of Ponds with Stunted Fish Populations," Tran. Am. Fish. Soc., 71:102-105, 1941.

TAYLOR, EDWARD H., "A Revised Checklist of the Snakes of Kansas," Univ. Kan. Sci. Bull., 19(5):53-62, 1929.

Tenth Biennial Report, For., Fish and Game Com., p. 15, 1944.

VAN OOSTEN, JOHN, "Life History of the Lake Herring (*Leucichthys Artedi Le Sueus*) of Lake Huron as Revealed by Its Scales, with a Critique of the Scale Method," Bull. U. S. Bur. of Fish., 44:1-507, 1928.

VIOSCA, PERCY, JR., Pondfish Culture, The Pelican Publishing Co., New Orleans, 250 pp., 1937.

WALL, ROY, "Fish and Fish Distribution," Seventh Bien. Rep. of the For., Fish and Game Commission, 1938.

WHEELER, WILLIAM, "A Partial List of the Fishes of the Marais Des Cygnes, at Ottawa," Tran. Kan. Acad. Sci., 6:33-34, 1879.

The High Plains Surface in Kansas

JOHN C. FRYE
State Geological Survey, University of Kansas, Lawrence

INTRODUCTION

The High Plains extend in a north-south belt for nearly a thousand miles (Fenneman, 1931, map) from south Texas to southern South Dakota and comprise the most extensive section of the Great Plains physiographic province. Western Kansas lies within the central High Plains (Fig. 1). This area, and the Llano Estacado of northwestern Texas and east-central New Mexico are probably most representative of the topography generally considered typical of this section (Pl. I). In these areas the High Plains are actually a partly dissected high plateau, sloping generally toward the east and southeast, the region as a whole being characterized by broad reaches of flat, undissected and in many places undrained uplands between the valleys. The major valleys that cross this plateau are broad and have gentle side slopes that extend downward to relatively narrow flats. Minor valleys in many places are steep-sided narrow canyons.

The Texas and New Mexico portion of the High Plains is terminated abruptly on the east and west by sharp escarpments capped by the Ogallala formation (Pls. 2B and 3B). In southern Kansas, Fenneman's (1931) eastern boundary of the High Plains is drawn at a minor topographic break located some 20 to 25 miles west of a prominent dissected escarpment in his Plains Border section. Northward, along the Arkansas Valley no perceptible topographic feature is found to mark the eastern limit of Fenneman's High Plains. Still farther north, in central and northern Kansas as far as the Nebraska line, the eastern margin is gradational across the belt of country called by Fenneman the Plains Border section (Pl. 2C). This section contains two irregular east-facing escarpments produced by the eastern outcrop of the Fort Hays limestone (Pl. 3A) and the Greenhorn limestone, but the eastern limit of the Ogallala formation produces an escarpment at only a few places.

EARLY CONCEPTS OF HIGH PLAINS SURFACE

Although the topographic features are quite obvious to anyone traversing the High Plains region, the character and age of the deposits, the age of the upland surface, and its Pleistocene history are more obscure. An early view, and one that has been persistently held by many geologists to the present time, is that the flat upland surface

Transactions Kansas Academy of Science, Vol. 49, No. 1, 1946.

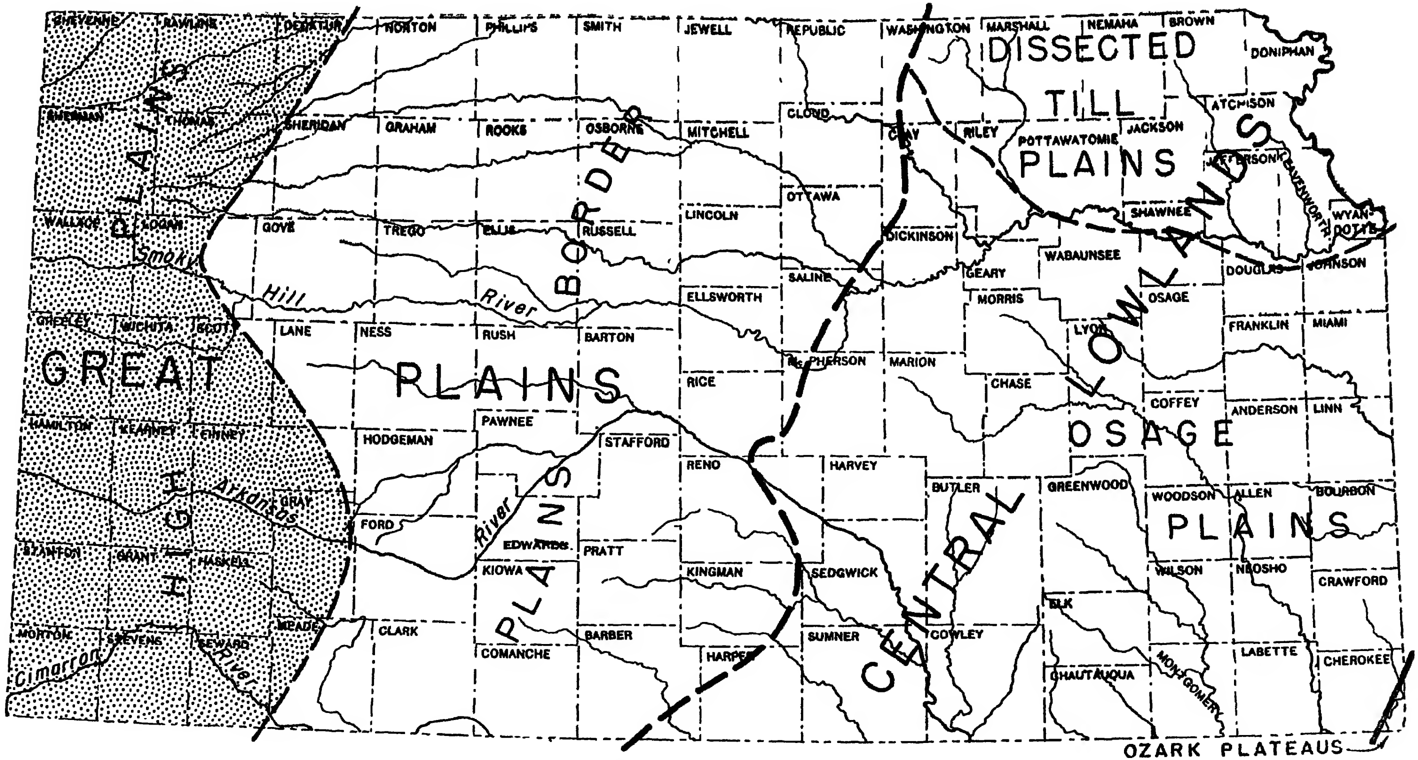


FIG. 1.—Physiographic divisions of Kansas. Enlarged from Fenneman (1931), Physical Divisions of the United States.

of the High Plains is the upper surface of Pliocene stream deposits now classed as the Ogallala formation, and that the topography of these interstream areas has remained essentially unchanged throughout Pleistocene and Recent time, protected by a cover of short grass (Haworth, 1897; Johnson, 1901). In 1901 Johnson (p. 629) stated: "The great plateau surfaces of the High Plains have to show no systems of drainage, because, presumably, from the commencement of the present erosion stage they have been sod-covered, as at present. In other words, the High Plains have endured as alluvial plateaus since Tertiary times, or at least since the opening of the Pleistocene." Two years later, Adams (1903, p. 122) expressed the same view in the statement, "Their surface is a constructional plain, which has survived in large measure since the close of Tertiary times. The divides between the streams are flats or fragments of an extended surface which was formed by the spreading of a quite even mantle of Tertiary sediments over the older rocks, which are principally of Cretaceous age."

Fenneman's (1931) treatise on the physiography of western United States presents essentially the same interpretation, stating (p. 11), "... these High Plains are remnants of a former great fluviatile plain which stretched from the mountains on the west to the Central Lowland," and further (p. 12), "Such deposits were made in this region in late Tertiary time and are frequently referred to as the 'Tertiary mantle'." As for the regional setting (Fenneman, 1931, p. 107), "It may be assumed that at the close of the later cycle the greater part of this province [Southern Rocky Mountains] and others adjacent were covered by a continuous graded plain, made by degradation of the mountains and aggradation of the Great Plains. The peneplain in the mountain province is believed to correspond in geologic date with the surface of the Pliocene sediments that now cover the High Plains."

Recent work in the Kansas High Plains (Smith, 1940; Frye, 1945a; 1945b) tends to confirm the conclusion that the surface of this region at the end of Ogallala deposition in late Pliocene time was a nearly flat alluvial plain which may have been continuous with the peneplain in the mountain region. There are many indications, however, that the area has been extensively modified by several cycles of erosion and deposition since Pliocene time, and it seems clear that much of the present High Plains surface was shaped in late Pleistocene and Recent times. The stratigraphy and structure of Tertiary and older rocks has exerted an influence on the Quaternary

history of the central High Plains, but only in Texas, where the Ogallala caprock is much thicker and more persistent than further north, does the Tertiary hold up a persistent and prominent east-facing escarpment.

TYPES OF TOPOGRAPHY IN THE KANSAS HIGH PLAINS

Several distinct topographic types are represented in the Kansas High Plains despite the low relief of the region. These types may be classed as (1) smooth flat uplands, (2) "dimpled" flat uplands, (3) "hummocky" flat uplands, (4) sand dune topography, (5) gentle smooth valley-side slopes or "pediment topography," (6) gently rounded convex ridges and concave gullies. and (7) alluviated and terraced valleys.

(1) The smooth flat uplands (Pl. 1) represent the extreme development of a featureless constructional plain. Except where sharp canyons slash the uplands, such surfaces deviate locally by less than a foot from the regional slope and locally exhibit no drainage pattern. This surface over much of the Kansas region is underlain by eolian silt or fine sand and fluvial deposits, and in the southern Llano Estacado region (Pl. 1C) by massive Ogallala caliche "caprock."

(2) "Dimpled" flat uplands are characterized by many irregularly spaced undrained depressions ranging from less than 1 foot in depth and 10 feet in diameter (Pl. 3D) to depressions more than 40 feet in depth and as much as a mile in diameter. The large solution-subsidence basins, such as the Ashland-Englewood Basin (Frye and Schoff, 1942), lie east of the High Plains as defined by Fenneman. Some of the High Plains depressions are due to solution in the Cretaceous chalk (Elias, 1930), and a few may be caused by solution of salt and gypsum at greater depth in the Permian. Evans and Meade (1945, p. 490) believe that eolian action is an important factor in producing shallow basins and their associated lee dunes in northwestern Texas. Some depressions may have originated through differential compaction produced by downward percolating water (Johnson, 1901, p. 703; Frye, 1945b, p. 30). Several large basins, such as the Meade Lake area (Frye, 1942, p. 31) and the Scott City Basin are related to faults and deep valley fills; locally these contain unique deposits of Recent alluvium (Frye, 1941).

(3) "Hummocky" flat uplands differ from smooth flat uplands in having scattered low gentle swells. In some areas these swells are believed to be subdued sand dunes. For example, near Minneola in Clark County the swells are associated with shallow depressions and seem to be homologous to "lee dunes" described from Texas

(Evans and Meade, 1945). Where the swells are not associated with depressions they are believed to be composed of silt and their origin is obscure.

(4) Sand dune topography is extensively developed in southern

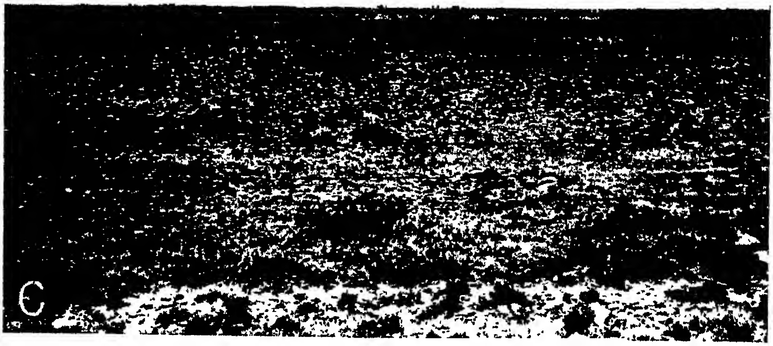


PLATE I.—The High Plains surface. A, Upland surface in Yuma County, Colorado, 7 miles west of the Kansas state line; B, upland surface south of Plains, Meade County, Kansas; C, upland surface 5 miles south of McDonald, Lea County, New Mexico.

Kansas where many dunes occur both on upland levels and on alluviated valley flats.

(5) Gentle, smooth valley slopes, believed to be produced by slope or pediment processes, have been described along Cimarron and Smoky Hill Valleys (Frye and Smith, 1942), and along the southern tributaries to Republican River (Frye, 1945b, p. 74); where such slopes characterize wide valleys they represent a distinct topographic type.

(6) Gently rounded convex ridges and concave gullies (Pl. 3E) characterize the topography of the side stream areas along some stretches of Cimarron and Smoky Hill Valleys and are typical of the region tributary to Republican River, both in the High Plains and Plains Border sections. Such topography is best developed in areas where thick massive loess overlies the Ogallala but apparently the sub-loess stratigraphy is not a controlling factor. Locally, in the Plains Border section, the concave floors of these gullies can be seen merging with stream terraces along the larger streams, but elsewhere they seem to be unrelated to stream terraces. Although the origin of these features is in doubt, they may have developed by the processes that gave rise to the "pediment-like slopes" along some of the major valleys.

(7) As suggested by Fenneman (1931, p. 25), alluviated and terraced valleys are not typical of the High Plains, although terraces have been described from several of the major valleys of the section. The major east-flowing streams are generally bordered by terraces in the Plains Border section.

AGE AND CHARACTER OF THE HIGH PLAINS SURFACE

South of Kansas.—The High Plains section south of Kansas in the narrow panhandle of Oklahoma and extending several hundred miles into western Texas and eastern New Mexico closely resembles the Kansas High Plains, at least superficially. The characteristics and age of the Llano Estacado surface, in the southern part of the section, differ somewhat from those of the Kansas region. In southeastern and east-central New Mexico and adjacent parts of Texas, the plains surface is immediately underlain by the so-called caliche caprock of the Ogallala formation (Pl. 1C); however, Price (1944) has pointed out that during late Pleistocene time at least part of this area was covered by a mantle of eolian sand that subsequently was largely removed by the winds. At present, the surface is a "smooth flat upland" having a thin soil and fragments of "caprock" on the surface. Locally, "dimpled flat uplands" prevail where shallow

saucer-shaped depressions are common, and "hummocky flat uplands" occur where residual sand remains. In this region, where a thick caliche caprock is at the surface, distinct escarpments mark

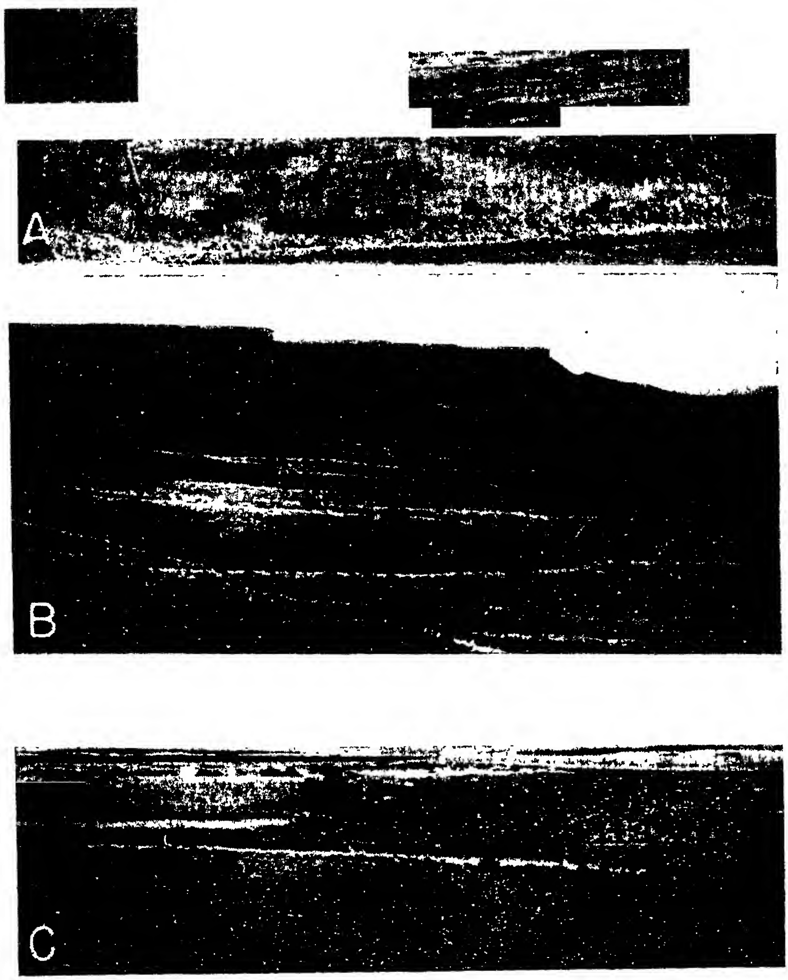


PLATE II.—The High Plains margin. A, Gypsum hills near the eastern margin of the Plains Border section, central Barber County, Kansas (photo by S. W. Lohman); B, west escarpment of Llano Estacado, Chaves County, New Mexico (photo by W. Armstrong Price); C, valley and loess topography of the Plains Border section, east-northeast from sec. 5, T. 5 S., R. 24 W., Norton County, Kansas.

both the eastern (Pl. 3B) and western (Pl. 2B) edges of Llano Estacado.

Northward, in the panhandle region of Texas, a mantle of tan to light brown silt and fine sand resembling the Kingsdown silt of Kansas in appearance, forms the plains surface. This surface is "smooth flat," and "dimpled" by saucer-shaped depressions and lee dunes (Price, 1944; Evans and Meade, 1945) and is cut by steep-sided canyons. It is quite similar to the surface in southwestern Kansas and was formed in late Pleistocene or Recent time.

Much of the Oklahoma panhandle region is occupied by the relatively broad valleys of the North Canadian (Beaver) and Cimarron Valleys (Schoff, 1939; 1943). These valleys are believed to have been cut during late Pleistocene and Recent time and their sloping sides are in many places mantled with deposits of Recent age. The small areas of flat uplands are partly mantled with eolian sand and massive silt and fine sand of late Pleistocene or Recent age.

Southwestern Kansas.—The portion of the Kansas High Plains lying south of Arkansas River consists predominantly of smooth flat uplands and sand dune areas which are broken by two major valleys. Smith (1940, p. 141) has described nine physiographic divisions in this region, including three flat upland areas, two valley areas along the Arkansas and Cimarron Rivers and the Finney sand plain. The Meade area as treated by Smith contains the valley of Crooked Creek and the Meade artesian basin, and it lies along the eastern edge of the High Plains as defined by Fenneman.

For the most part, the entire High Plains region is underlain at various depths by the Ogallala formation. At some places in Stanton County however (Latta, 1941), Lower Cretaceous rocks crop out along shallow valley sides and even at the High Plains level, or they are covered only by a thin veneer of Pleistocene sediments; in Morton and Hamilton Counties, Triassic and Upper Cretaceous rocks are exposed (McLaughlin, 1942; 1943). Ogallala deposits are exposed at the upland level only in the counties bordering the Colorado line, and in counties farther east along major valleys.

The topography of southwestern Kansas is in part constructional, but has been modified importantly by other processes. At the close of Ogallala deposition, an alluvial constructional plain of low relief sloped east-southeastward across this region, but little if any of this plain is preserved in the present topography. During early Pleistocene time, the Ogallala was extensively dissected. In Meade County, along the eastern edge of the High Plains, faults

show a displacement of both Ogallala and Pleistocene strata. Solution-subsidence basins are filled with middle and upper Pleistocene deposits, and in several areas such as lower Crooked Creek Valley (Frye, 1942, p. 31), such basins have exerted a controlling effect on the location of present drainage lines. The most striking topographic break of the plains occurs in western Clark County, where a coalescing series of such partly filled subsidence areas forms the Ashland-Englewood Basin.

Westward from this marginal area, the uplands present a relatively unbroken expanse except for the trough of the Cimarron River and a few major tributaries. However, the presence of a varied sequence of Pleistocene deposits below this surface records a history of erosion and fill since the close of Tertiary time.

A terrace of late Pleistocene age occurs along the Cimarron Valley and is believed to be contemporaneous with the lower part of the widespread Kingsdown silt that mantles much of the uplands. These deposits grade upward into massive tan silt believed to be of eolian origin. The upper Kingsdown silts and dune sands together constitute the upland surficial deposits of most of this region; thus the surface is of late Pleistocene and Recent age.

The eastern limit of the High Plains in southwestern Kansas, as drawn by Fenneman, seems to be somewhat arbitrary. In Meade County the limit roughly coincides with a local steepening of surface slope west of a faulted zone along Crooked Creek Valley and the basin of the late Pleistocene Meade Lake; however across Gray County there is no recognizable break in topography at this line. In east-central Meade County and northwestern Clark County the upland flats present all the characteristics of the High Plains. A prominent topographic break occurs in southeastern Meade County and central Clark County. If subsequent detailed studies result in an eastward shift of the High Plains boundary this topographic break, which is easily recognizable in the field, could serve as a dividing line between High Plains and Plains Border. Furthermore, such a boundary projected northward across the Arkansas Valley would intersect the area of dissected Cretaceous strata along Sawlog Creek, about 30 miles to the north, and so have a minimum amount of its length unsupported by a topographic feature.

The Arkansas Valley west of Hartland is filled with Recent alluvium lying in a trough cut through the Ogallala and into the Cretaceous bedrock (McLaughlin, 1943). East of Hartland it is bordered on the south by a broad alluvial plain, mantled with dune

sand, and on the north for the most part by a distinct escarpment cut in Ogallala and Pleistocene deposits (Latta, 1944).

Region between Arkansas and Smoky Hill Valleys.—Across much of the High Plains section of Kansas, the Arkansas Valley is sharply bounded along the north side by low bluffs exposing Cretaceous strata and the Ogallala formation. In an area extending 50 miles east from the Colorado line, the surface of the plains extends in an almost unbroken expanse from the Arkansas Valley northward to the break in topography marking the southern limit of the Smoky Hill Valley, and long fingerlike projections of this surface extend as much as 25 miles farther east along the divide areas. In this region, Smith (1940, p. 141) has described two upland areas—Kearny and Kalvesta—separated by the Scott-Finney depression. These upland areas are underlain at shallow depths by the Ogallala formation, and at some places the Ogallala constitutes the rock immediately below the soil.

In the eastern upland areas, particularly in Lane County, the upland is mantled by fine to medium sand that locally gives the appearance of widely spaced and greatly subdued dunes, producing a "hummocky" flat upland. Although detailed geomorphic studies have yet to be made in this area it is believed that this surficial mantle is largely Pleistocene to Recent in age.

The Kearny upland area extends westward into Colorado. It presents a flat smooth upland surface that is partly mantled by deposits of massive tan silt. At some places in this area, the Ogallala immediately underlies the soil, whereas elsewhere the surficial silts attain a thickness of more than 50 feet. These silt deposits have many characteristics in common with the Kingsdown silts of late Pleistocene and Recent age that occupy a comparable position south of Arkansas River. In southern Wallace County they have been included by Elias (1931) in the Sanborn formation, which is classed as Pleistocene.

Smith's Scott-Finney depression is an elongate topographic sag extending most of the distance from Smoky Hill Valley to Arkansas River and containing the undrained Scott City Basin in central Scott County. The surficial deposits over at least part of this depression area are continuous with the massive tan silts; however, studies by H. A. Waite now in progress reveal the presence of more than 100 feet of stream-deposited sand and gravel of Pleistocene age lying below the surficial silts and filling the lower part of a trough—in some places resting directly on Cretaceous bedrock. It seems prob-

able that this trough is erosional and is a segment of the early to mid-Pleistocene drainage pattern which had a quite different alignment than the present drainage pattern.

The Smoky Hill Valley.—The broad band of the Smoky Hill Valley transects the High Plains of Kansas and except for a small area in western Wallace County, Kansas, and Cheyenne County, Colorado, it would join with the valley of Big Sandy Creek in Colorado in producing a sizable strip across the entire region devoid of Tertiary sediments. Across the western half of Fenneman's Plains Border section and the High Plains in Kansas this valley is 12 to 20 miles wide and is underlain by shales and chalks of late Cretaceous age. The valley margins are generally marked by low but relatively steep escarpments developed in thin Ogallala strata or in chalk or chalky shale where the valley crosses the belt of Niobrara outcrop. Most of the valley area between the marginal escarpments is characterized by relatively gentle slopes, called by Frye and Smith (1942) "pediment-like slopes;" these slopes are mantled by a veneer of sediment believed to be in intermittent transit toward the stream channels. The present flood plain is narrow, accounting for less than 5 per cent of the total width of the valley in many places, and it is believed that the valley has been largely developed by the operation of slope processes—the major streams serving merely as transportation lines for the sediment brought to them. In the western part of the Plains Border, there are fragmentary stream terraces along the main valley and in the eastern half of this section the Smoky Hill Valley has the aspect of a stream-terraced valley having relatively abrupt valley walls and broad terrace surfaces at several levels (Frye, Leonard, and Hibbard, 1943). That the Smoky Hill Valley has developed during the Pleistocene is clearly attested by its relationship to the Ogallala strata along its margins. That it has attained its present configuration during the latter part of Pleistocene and Recent time is indicated by its relation to the Pleistocene deposits in the Scott-Finney depression, by the terraces that have been studied to the east of the High Plains area, by the presence of Sanborn deposits capping the uplands along its margins, and by the young age of the deposits that mantle the valley slopes.

Northwestern Kansas.—In the region of northwestern Kansas, north of Smoky Hill Valley and south of the Republican Valley in southern Nebraska, the High Plains contain the headwaters of many streams, including the Saline and Solomon Rivers and Prairie Dog and Sappa Creeks. It is this part of the High Plains that Smith

(1940, p. 84) believes contains the axis of post-Ogallala warping. The plains topography in Sherman and southern Cheyenne Counties, Kansas and adjacent Kit Carson and Yuma Counties, Colorado (Pl. 1A) presents a smooth flat surface that becomes "dimpled" with shallow depressions, or "buffalo wallows" in Thomas and adjacent counties (Pl. 3C and 3D). In this part of the state the uplands of the High Plains and the western half of the Plains Border are mantled by a nearly continuous blanket of loess, classed as the upper part of Elias' Sanborn formation (Elias, 1931; Frye, 1945). This loess, which is generally 30 to 50 feet thick, is believed to be late Pleistocene to Recent in age, and to be largely of eolian origin. The Ogallala formation underlies the Pleistocene deposits of virtually all of the High Plains and the western margin of the Plains Border in northwestern Kansas and extends eastward along the major divides more than 160 miles east of the Colorado state line.

Along many of the valleys of northwestern Kansas the topography is characterized by gently rounded convex ridges and concave gullies as shown in Plate 3E. Gullies of this type occur throughout much of the Kansas High Plains, particularly where the surficial deposits consist largely of silt, but are most abundant in this region. Such features seem to represent a development in miniature of the "pediment-like" slopes described along the major valleys farther south.

An almost complete gradation (Pl. 2C) occurs between the flat uplands along the Kansas-Colorado line and the maturely dissected medium- to coarse-textured topography of eastern Norton and Phillips Counties. Fenneman apparently drew the eastern boundary of the High Plains quite arbitrarily across this region through southeastern Thomas County and central Decatur County. There is no recognizable topographic break along this line, and quite logically it could be shifted eastward more than 50 miles, particularly in the area immediately north of Smoky Hill Valley.

North of Kansas.—The loess plains and loess hills topography of northwestern Kansas continues northward into western Nebraska. The southwestern part of that state is largely mantled by surficial deposits of late Pleistocene to Recent age (Lugn, 1935), typified by the widespread loess in the southern part, and the extensive sand dune tracts farther north. Fenneman (1931, pp. 16-17) has suggested four subsections of the High Plains in the region north of Kansas; namely, the area underlain by the Arikaree formation on the west and north, the loess on the east and south, and the sand hills in

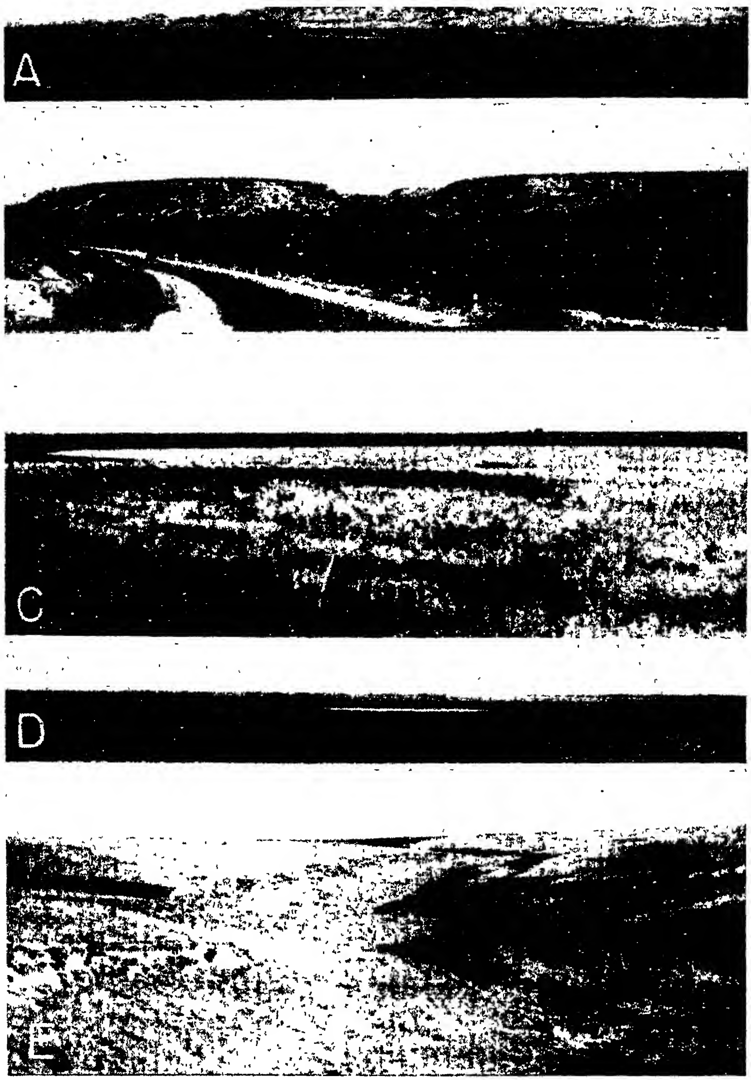


PLATE III.—Special features of High Plains and Plains Border topography. A, Escarpment of Fort Hays limestone over Carlile shale, northeastern Ellis County, Kansas; B, east escarpment of Llano Estacado, east of Floydada, Texas; C, undrained upland depression in the High Plains of northwestern Thomas County, Kansas; D, shallow High Plains depression, north-central Thomas County, Kansas; E, steep-sided, concave-bottomed gully developed in loess overlying the Ogallala formation in the High Plains of east-central Rawlins County, Kansas.

the center. He suggested a fourth subdivision in the north as the Goshen Hole lowland underlain by Brule clay. For reasons not clearly evident in the topography, Fenneman abruptly changed the direction of the eastern boundary line of the High Plains as drawn by him northward from Kansas, so that it runs eastward roughly parallel to the Nebraska-Kansas state line, and thus terminates the Plains Border section in southern Nebraska. This physiographic districting is difficult to accept as the topography included in the expanded High Plains section of Nebraska has as many characteristics in common with the Plains Border as with the High Plains in the region immediately adjacent on the south, even though it lacks (Fenneman, 1931, p. 26) the prominent escarpments produced by the Cretaceous limestones in Kansas.

CONCLUSIONS

The surface of the central High Plains does not represent the upper surface of the fluvial Ogallala sediments, preserved by a cover of sod without significant change throughout Pleistocene time. Although this region has probably been a plains country of low relief since the withdrawal of the Cretaceous seas, the present topography is mainly a result of events occurring during Pleistocene and Recent time. Regionally, the Pleistocene cover is largely absent from the High Plains surface in its southernmost extent and increases in thickness and extent northward through the section, although exception to this generalization is found in the thick sequence of post-Ogallala sediments in the Meade Basin region of southwestern Kansas and Oklahoma.

The Pleistocene deposits of the central High Plains furnish record of history that includes dissection and fill along the major valleys; extensive modification of the drainage pattern; movement along fault planes; development of solution-subsidence depressions; filling of basins and depressions; widespread eolian activity resulting in extensive blankets of loess and dune sand; and Recent dissection and development of the present topography.

The southern High Plains are bounded both eastward and westward by prominent escarpments. In the central and northern parts of the High Plains section, however, at least the eastern margin of this plateau is transitional across a wide belt that in Kansas contains several escarpments produced by flat-lying pre-Tertiary strata. Fenneman's section boundary line across this area seems to be drawn quite arbitrarily and is placed much farther west than the limit of the High Plains defined by Adams (1903, p. 113). A critical study

of this region would probably lead to an eastward shift of Fenneman's eastern limit of the High Plains in Kansas and to greater consistency in the grouping of topographic types in Nebraska and Kansas assigned to the Plains Border and High Plains sections.

Acknowledgments.—Thanks are expressed to R. C. Moore, Bruce F. Latta, and Ada Swineford who have read and criticized the manuscript.

REFERENCES

Adams, George I. (1903) Physiographic Divisions of Kansas. Kansas Acad. Sci. Trans., vol. 18, pp. 109-123.

Elias, Maxim K. (1931) The Geology of Wallace County, Kansas. Kansas Geol. Survey, Bull. 18, pp. 1-254.

——— (1930) Origin of Cave-ins in Wallace County, Kansas. Am. Assoc. Petroleum Geologists Bull., vol. 14, no. 3, pp. 316-320.

Evans, Glen L., and Meade, Grayson E. (1945) Quaternary of the Texas High Plains. Univ. of Texas Publ. No. 4401, pp. 485-507.

Fenneman, N. M. (1931) Physiography of Western United States. New York, McGraw-Hill Book Co., pp. 1-534.

Frye, John C. (1941) Some small scale natural levees in a semi-arid region. Jour. Geomorphology, vol. 4, no. 2, pp. 133-137.

——— (1942) Geology and Ground-water Resources of Meade County, Kansas. Kansas Geol. Survey, Bull. 45, pp. 1-152.

——— (1945) Problems of Pleistocene Stratigraphy in Central and Western Kansas. Jour. Geology, vol. 53, no. 2, pp. 73-93.

——— (1945a) Valley Erosion since Pliocene "Algal Limestone" Deposition in Central Kansas. Kansas Geol. Survey, Bull. 60, pt. 3, pp. 85-100.

——— (1945b) Geology and Ground-water Resources of Thomas County, Kansas. Kansas Geol. Survey, Bull. 59, pp. 1-110.

Frye, John C., Leonard, A. Byron, and Hibbard, Claude W. (1943) Westward Extension of the Kansas "Equus Beds." Jour. Geology, vol. 51, no. 1, pp. 33-47.

Frye, John C., and Schoff, Stuart L. (1942) Deep-seated Solution in the Meade Basin and Vicinity, Kansas and Oklahoma. Am. Geophysical Union Trans., pt. 1, pp. 35-39.

Frye, John C., and Smith, H. T. U. (1942) Preliminary Observations on Pediment-like Slopes in the Central High Plains. Jour. Geomorphology, vol. 5, no. 3, pp. 215-221.

Haworth, Erasmus (1897) Physiography of Western Kansas. Kansas Univ. Geol. Survey, vol. 2, pp. 11-49.

Johnson, Willard D. (1901) The High Plains and Their Utilization. U. S. Geol. Survey, 21st Ann. Rept., pt. 4, pp. 601-741.

Latta, Bruce F. (1941) Geology and Ground-water Resources of Stanton County, Kansas. Kansas Geol. Survey, Bull. 37, pp. 1-119.

——— (1944) Geology and Ground-water Resources of Finney and Gray Counties, Kansas. Kansas Geol. Survey, Bull. 55, pp. 1-272.

Lugn, A. L. (1935) The Pleistocene Geology of Nebraska. Nebraska Geol. Survey, Bull. 10, pp. 1-223.

McLaughlin, Thad G. (1942) Geology and Ground-water Resources of Morton County, Kansas. Kansas Geol. Survey, Bull. 40, pp. 1-126.

——— (1943) Geology and Ground-water Resources of Hamilton and Kearny Counties, Kansas. Kansas Geol. Survey, Bull. 49, pp. 1-220.

PRICE, W. ARMSTRONG (1944) Greater American Deserts. Texas Acad. Sci. Proc. and Trans., vol. 27, pp. 163-170.

——— (1944a) The Clovis Site: Regional Physiography and Geology. Am. Antiquity, vol. 9, no. 4, pp. 401-407.

SCHOFF, STUART L. (1939) Geology and Ground-water Resources of Texas County, Oklahoma. Oklahoma Geol. Survey, Bull. 59, pp. 1-248.

——— (1943) Geology and Ground Water Resources of Cimarron County, Oklahoma. Oklahoma Geol. Survey, Bull. 64, pp. 1-317.

SMITH, H. T. U. (1940) Geologic Studies in Southwestern Kansas. Kansas Geol. Survey, Bull. 34, pp. 1-244.

Birds on Tinian in the Marianas[1]

THEODORE DOWNS, 1st. Lt.,
Medical Administrative Corps, U.S.A.

Abstract: A discussion of observations and notes on birds of Tinian Island. Fifteen species and subspecies were observed and identified by the author during a period of six months duty with the army. A locality map and summary chart are included.

I. INTRODUCTION

The purpose of this article is to present a record of ornithological observations conducted on the island of Tinian in the Pacific Ocean. It is by no means a complete treatise, but represents merely the observations that time, conditions and circumstances allowed during a tour of duty with the U. S. Army Air Forces on Tinian Island. The period included extended from May 31 to October 17, 1945. During the time available the author participated in several field trips, recording a total of 58 separate observations throughout the course of 130 days residence on the Island. Firing of weapons was prohibited; therefore, it was impractical to obtain representative specimens. A sling shot was used to obtain one specimen, the Tinian Monarch. The other identifications are based on observations through the use of field glasses, notes and original color sketches. A copy of *Birds of the Southwest Pacific* by Ernst Mayr

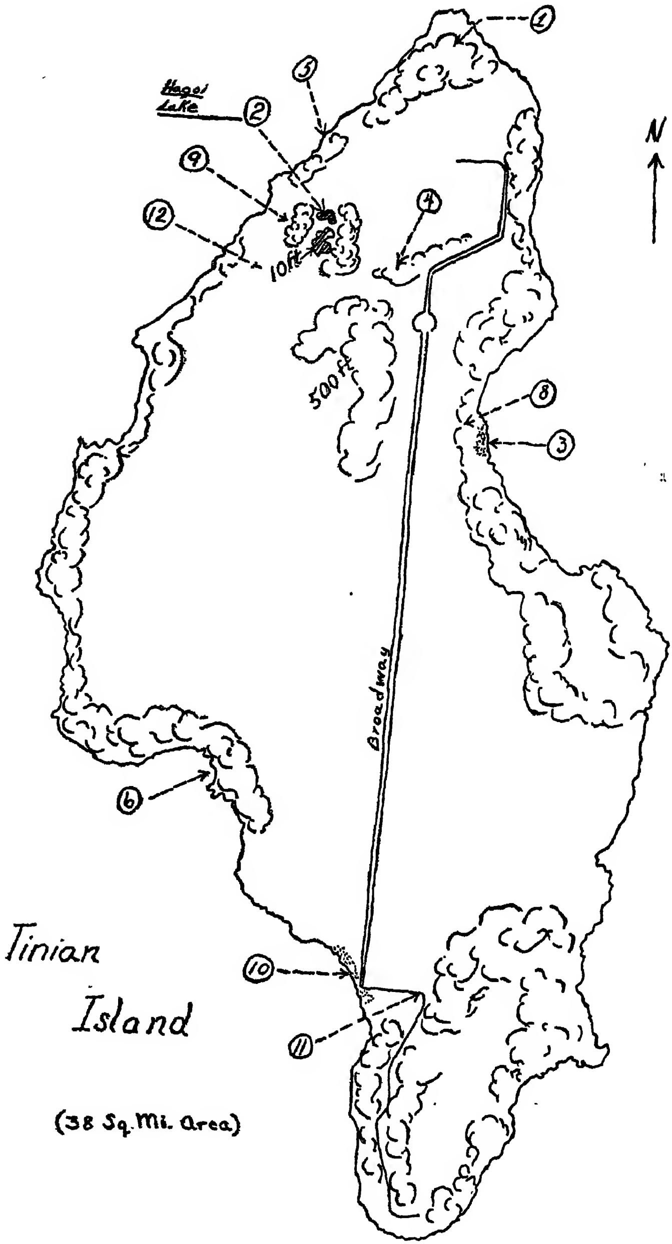
Summary Chart of Birds of Tinian—1945.

1. *Name*	2. *Incl. Dates of Observations*	3. *Distribution*	4. *Avg. Rate of Occurrence*	5. *Rates of Occurrence*
1. Reef Heron	21 July—11 Oct.	2,9,10,12	3	1-10
2. Chinese Least Bittern	3 June—12 Oct.	1,2,5,9,12	2	1-6
3. Moorhen	26 July—12 Oct.	2	2	1-5
4. Pacific Golden Plover	5 Sept.—22 Sept.	9	5	2-12
5. Wandering Tattler	18 Sept.—12 Oct.	10	2	1-3
6. Fairy Tern	11 June—15 Sept.	4,8,12	4	2-8
7. Marianas Fruit Dove	12 July	12	1	1
8. Philippine Turtle Dove	29 May—17 Oct.	1 thru 13	7	1-17
9. White Throated Ground Dove	11 June—8 Sept.	2,4	1	1-2
10. White Collard Kingfisher	2 June—17 Oct.	2,4,6,8,12,13	2	1-4
11. Rufous-fronted Fantail	7 Sept.—12 Oct.	2,11	2	2
12. Tinian Island Monarch	7 June—12 Oct.	1,2,4,10,11	2	1-4
13. Micronesian Starling	21 June—12 Oct.	2,4,8,9,12	4	1-8
14. Cardinal Honey Eater	8 June	1	2	2
15. Bridled White-Eyes	2 June—17 Oct.	1,2,4,8,9, 10,11,12	8	2-25

1. Common names taken from Mayr, *Birds of Southwest Pacific,* 1945.
2. The first and last observation dates.
3. Each number refers to locality number on outline map.
4. Computed average count of birds on any one trip.
5. The maximum and minimum number seen on all trips.

Transactions Kansas Academy of Science, Vol. 49, No. 1, 1946.

[1]This article has been approved on grounds of military security or policy by the War Department Bureau of Public Relations, in a letter dated 23 January 1946.


Hagoi Lake
1
2
3
4
8
3
9
12
10ft
500ft
Broadway
N
6
10
11
Tinian
Island
(38 Sq. Mi. Area)

(1945), became available to me for a period of one week while I was still on the Island and at that time the identifications were made on the basis of the nomenclature and descriptions in Mayr's book by comparison with the records made previously.

Tinian is located about 145° longitude, east of Greenwich, and 15° north latitude as a part of the series of the Marianas Islands. Nearly three miles north and across a channel is Saipan; south about three miles is Aquijan, a very small island. Tinian has a regular ter-

A shoreline on the west side of Tinian Island.

rain of low hills and cliffs partially covered with forest, many fields of sugar cane, numerous heavily traveled and isolated roads and an abundance of military installations. At no point is the elevation over 600 feet and we saw no streams, but drainage lanes, pools and one small lake are present. The average temperature is about 78° F.

Insects are exceptionally numerous. No wild mammals were seen and just one snake observed. Skinks and "geckos" appeared to be the most common reptiles and toads were the only amphibians on the island. There was evidence of a well established population of small minnows in Lake Hagoi; also one fish of larger size was observed there.

Observations were often curtailed because of the restricted areas and possibility of Jap snipers and unexploded booby traps. I was accompanied on many of these excursions by Sergeant Eugene Cypert of Searcy, Arkansas, and 1st Lt. Joel Canby of Denver, Colorado, both of whom were very helpful in spotting specimens and verifying identifications. Later, on return to the United States, Dr. John Breukelman of the Emporia State Teachers College, Dr. C. W. Hibbard, and Dr. D. S. Farner of the University of Kansas, supplied helpful criticism and assistance in final checking and compilation of these notes.

II. SPECIFIC NOTES

ORDER CICONIIFORMES

FAMILY ARDEIDAE

1. Reef Heron. *Demigretta sacra sacra* Gmelin. According to Mayr (1945 p. 284) the heron of the Mariannas is this race although Peters (1931 p. 112) recognizes no subspecies. The herons appeared in two distinct phases, gray and white. Of the two, the white phase was much more common and was found only within or near the area of the fresh water lake. The two gray birds observed were seen along the south beach location No. 10.[2] They were stalking their food together, and were rather unconcerned with the presence of an observer as they meandered leisurely along the shore stretching their long legs forward and reaching down with their gray bills to grasp their prey.

Hagoi Lake, the one fresh water lake, contained a great deal of marsh grass and water plants. It was in the environment of this irregularly bordered lake surrounded and interrupted by thick vegetation that we were always certain to find a white phase of these herons feeding alone along the edges of the shallow pools. Beyond our reach and observation, toward the center of the lake the birds were usually seen roosting on the low trees.

On most occasions we saw the herons in groups of three to ten. When seen singly the birds seemed to be feeding, especially

---

[2]Refers to numbered location on the accompanying map.

when one was flushed from the edge of the pool. These pools containd evidence of many minnows and possibly these fish were part of the heron's food. On the higher parts of the island we located several temporary rain puddles or ponds where toads in the tadpole stage were common, and a single white heron was observed apparently waiting to obtain some of the tadpoles. It seemed to be a common occurrence for them to pick up small rocks or pebbles, for at various times we were able to watch them picking up material on a road bed or in the open cultivated fields. These birds were relatively wary of humans and never allowed one to approach closer than fifty to seventy-five yards.

In the white birds the identifying features were an all over pure white body, a bright orange-yellow bill, and green-black legs. They stood about two and one-half feet high and in general appearance they resembled the American Egret. The gray phase was distinguished by its all over blue-gray body varying only in light or dark hues in the neck, wings and under parts. The bill was a dark slate-gray matching the body, and the legs were green-yellow.

2. Chinese Least Bittern. *Ixobrychus sinensis* Gmelin. The first impression of this bird suggests a Little Green Heron. In good light, however, the differences become obvious. The bittern was seen in nearly every type of habitat, from one end of the Island to the other. Once or twice it was seen in the shadows of the jagged rocks of the more quiet beaches, then frequently they were seen to slip between the tall leaves of the valley sugar cane, or flying higher toward an upland feeding spot, and we could always count on watching them in the vicinity of the lake. Whenever their flight was observed it seemed to be very direct; once the jeep in which we rode nearly killed a low, straight flying bittern. Usually they were seen in flight in the cooler part of the day or when it was cloudy. The only evidence of voice we could discern was a "prruck" or "chrruck", and often we could hear these calls in the tall reeds. On one occasion they were seen in pairs, most other observations were of single specimens, but as many as six different birds were seen on one trip to the lake on July 25. I was able to approach a gawking bird within about ten to fifteen feet after working through the muck and weeds with considerable effort. Even then it was possible to get a close look for a few seconds only. The bittern watched me very closely as I noted its characteristic markings, blending so well with the surroundings. It had a bill six to eight inches long with a yellow-green mandible, a brownish maxilla, and the slim

neck seemed a good twelve inches in length when stretched out with its merging streaks of brown and yellow. The body was a dark brown tinged with soft green on the wings and flanks. There were streaks of yellow and brown on the breast and belly, and a very distinctive characteristic always noticeable when this bird was in flight, was the dark blue-gray "flash" color of the outer wing tips or primaries.

ORDER GRUIFORMES

FAMILY RALLIDAE

3. Moorhen or Gallinule. *Gallinula chloropus guami* Hartert. The moorhen seemed to be definitely restricted to the fresh-water lake. Usually these Gallinules were seen feeding in groups of two or three, and sometimes alone. Their food seemed to be situated in the confines of the edges of the marshy pools, although on one occasion a bird was flushed from an isolated puddle about four or five feet above the level of the marsh, and minnows were also stranded in this shallow pool. Frequently a hen would be startled from its feeding along the shore and it would cluck and clatter with flaying feet across the water, wings beating frantically and water spraying, gliding for a few yards, then quickly settling down on the surface of the water.

On September 7th, we were fortunate enough to watch five of these birds on the lake perform in an unusual manner. It appeared to be a form of courtship. The white bar on each side of the tail and flanks was much more prominent than before and they seemed to be flashing the white in a strut. Frequently one bird would swim directly toward another, with head lowered, nearly touching the water, and swimming along rapidly. It would even jump from the water in order to gain a little distance, as the bird being pursued swam somewhat faster but kept its head erect and oscillating back and forth in the usual moorhen manner. Together with this behavior intermingled croaks and "kaks" were uttered and occasionally the birds would lift themselves into a standing position above the water and then settle themselves back down again. Variations of these maneuvers were achieved intermittently for fifteen or twenty minutes.

The markings of these birds were always readily apparent. The bright yellow spot on the tip of the bill and the brilliant vermillion forehead and upper bill were outstanding, in contrast to the black body and likewise in contrast were the white feathers along the sides of the tail and belly. Their infrequent, abbreviated flight

resembled our familiar "mud hen" or coot. During one visit to the Lake a much disintegrated body of one of these birds was discovered. Most of the bird was gone with the exception of a few feathers, the bill and the feet. The bottom surface of the long chicken-like toes had flat flanged portions of skin tapering distally. This slight flange extended back to the base of the toe which was not more than an eighth to a fourth of an inch wide at the widest portion.

ORDER CHARADRIIFORMES

FAMILY CHARADRIIDAE

4. Pacific Golden Plover. *Pluvialis dominica fulva* Gmelin. The plovers were visitants during the course of their fall migration as evinced by their sudden appearance in small flocks after September 5th; usually five to seven were observed, but a total of twelve birds were counted at an open cultivated field (No. 9), not far from the woods surrounding Hagoi Lake. We usually found the plovers in the open terrain, feeding singly upon the expanse of the cleared field, but when aroused they would fly up with an excited "queedle", and then several would gather together at another portion of the field. It was easy to observe these birds with field glasses, in fact on one occasion a plover stood motionless and persistantly stared for six or eight minutes. Often these slim necked birds would fly for a short distance, alight and turn their eyes to stare at us again.

The coloration of these vagabonds presented considerable variation. There were those with the typically dark head and white-golden streak extending above the eye downward to fuse into the white or black spots of the neck and breast. All of the birds possessed a characteristic short, blunt, black bill, and a back and wings of mottled brown touched in soft golden spots alternating with dark flecks. Many of the birds wore an obvious black or black-brown streak at the nape of the neck and the upper back. In contrast to this coloring, other specimens showed no white or dark tones, but rather had an all-over mottled brown features. As aids to decisive identification we saw no white flash colors when they winged away and displayed the narrow pointed wings and drab upper surface of the tail.

FAMILY SCOLOPACIDAE

5. Wandering Tattler. *Heteroscelus incanus* Gmelin. Opportunities to observe these birds were limited, but their habits on the few occasions we did see them allowed fair observation because they were not unduly excited by our approach, and were somewhat

erratic in their habit of sudden spurts down the shore line, interrupted by an occasional stop to teeter, but they never seemed to pick up any food. The procedure was all a part of aimless wandering; however, at times they found something of interest in the fringing pools or on the ragged coral rocks, such as the garbage that happened to be prevalent in this area, since one of the military dumps was situated on the shore. My first observation was on September 18th, and the last on October 12th, and such a specific period of time would indicate that the Tattlers were in migration. It may be significant to note there were never more than three seen in one group.

The structure most obviously notable was the long slim, black bill, blunted distally and almost exaggerated in its extreme proportionate length. The crown feathers were dark but across the forehead a "v" shaped white streak extended back laterally above the black eye. The main portions of the remaining parts of the body were gray, lighter around the slim neck; below the neck fine dark spots appeared with increasing frequency downward along the breast and changed into a barred appearance throughout the belly and flanks, offset with a pure white background. The feathers along the thighs were completely white as were the vent and small portion of the belly. The thin legs were a bright yellow. According to Mayr (1945 p. 43), these birds would be classified as *Heteroscelus incanus incanus* Gmelin. There was one bird however, that appeared to be an exception to the others in that it was definitely white over the entire surface of the belly and the breast. This specimen might have been *Heteroscelus incanus brevipes* Vieillot or possibly a fall phase of the former. In flight all of the tattlers seemed gray dorsally displaying a short dark tail and sounding their plaintive "peerwee, peerwee".

FAMILY LARIDAE

6. FAIRY TERN. *Gygis alba candida* Gmelin. We were certain from our first observation that these beautiful white aerialists must be some kind of tern because of their common habit while in flight of holding the bill and head at right angles to the body, pointed downward. Observations of the terns were made from a distance as near as seventy-five yards as they alighted or perched upon a vertical cliff side (No. 4). They had pure white bodies; completely so, except for the jet black eyes and bill. The blackness of the bill seemed to extend a little beyond the base of the mandibles but did not join the eye. The tail always displayed its sharply forked outline when the bird was in flight.

These terns seemed to be inhabiting the vicinity of the inland cliffs most of the time, because they were never see near the shoreline cliffs nor over the surface of the ocean. The areas where I did find them were along Broadway and locality No. 4. At almost any time of the day we watched at least one or two of the terms wheeling about over the edge of the cliff. Their smoothness and variation in flight was exceptional. For instance, on one occasion it actually appeared there were three of them purposely flying together in a tight staggered formation; dipping, turning, climbing and descending in perfect unison, one slightly to the rear of the other and frequently they would cross paths in their circling. It was much more common to see them flying in pairs; the greatest number seen together in flight was eight. Their attempts to land on one of the many crooked roots or branches of the short trees growing on the vertical slope of the cliff side was rather comical because when alighting they had difficulty in keeping their equilibrium and would flutter in mid-air then more or less fall on the branch, hesitate and flutter up again for a second landing. Often they were seen resting on these perches for extended periods.

COLUMBIFORMES

FAMILY COLUMBIDAE

7. Marianas Fruit Dove. *Ptilinopus roseicapillus* Lesson. Although seen on just one occasion there could never be doubt in the identification of this dove because of the bright vermil-

An inland cliff site, frequented by the terns, doves, and starlings.

lion or rose colored face, forehead and portion of the crown. It flew into a wooded section near the group area (No. 12) and apparently was not aware of my presence. The bright coloring of the face extended up over the forehead and a little below the mandible on the throat; the rest of the body was in general a beautiful blue-green with different shades of light and dark, the upper breast centrally spotted in a maroon shade, and the belly, flanks, and vent were a bright orange- yellow. The upper surface of the tail was a greenish-blue cast similar to the feathers of the back. The dove puffed out its neck and cooed for a moment then quietly flew away. Peters (1937 p. 31) has limited this Fruit Dove to Saipan, Tinian, Rota and Guam, in distribution.

8. PHILIPPINE TURTLE DOVE. *Streptopelia bitorquata dusumieri* Temminck. Judging from the limited amount of literature I have been able to read, this is the only introduced bird encountered. The distinctive markings included a conspicuous lavender-gray patch almost square in outline on the back of the neck, a buff tan tinge to the head, neck and underparts; and bluish purple-gray back and wings with a long tail fringed in a quarter-inch border of white, the latter color obvious when in flight. I would judge that the bird is about the same length as our pigeon, and similar in habits. These birds were often feeding under the low brush just outside our quonsets or hutments, flying away at the too curious approach of humans.

In regard to their local distribution we may note that they were seen along the sea shore, near cliffs, on trees, down in the open fields and the lake area; but seemingly the most frequent places of rest were the many telephone lines, as was illustrated by the position of seventeen birds counted in one observation on one section of a telephone line. Usually they were encountered in pairs or small groups roosting in the trees, on the lines, or on the ground feeding, and often at those times their soft "coork-cooo" could be heard in the distance especially early in the mornings. Sometimes their necks could be seen to puff out and heads bob as they emitted the call. The Philippine Dove had become very abundant and with the apparent complete protection from hunters that it enjoyed, it should become much more common. It was, along with the White-eyes, the most frequently observed bird. The chief enemy seemed to be the army vehicle speeding across their habitually low courses of flight.

9. WHITE-THROATED GROUND DOVE. *Gallecolumba xanthanura xanthanura* Temmick. This very elusive ground dove was seen on

four occasions; and each time the distinctive markings were evident as was indicated by the nearly white head with neck and upper breast in sharp contrast to the cinnamon brown extending over all the rest of the body. The Ground Dove possessed a large pigeon like bill, round head, and proceeded with the careful, short, quick step of the dove or pigeon. Upon watching the bird in flight the wings appeared rounded at the tip, but that was not definitely established.

The outstanding habit of this bird was its wildness and very quiet actions; so well demonstrated when from the cover of dense vine growth or trees it would appear suddenly and fly straight for concealment in another area. It was never observed to alight out in the open, and only through luck our one good observation occurred when a single dove was surprised along the Hagoi Lake shore up in the branches of a papaya tree. It was peering cautiously and carefully moving up the narrow branch, then stopping and nervously nodding its head back and forth to obtain a view of us. Rather suddenly it slipped away backward through the foliage and completely out of range. It was always seen alone, and those instances of observations were confined to the vicinity of the lake area (No. 2) and the forested part of the cliff side (No. 4).

ORDER CORACIIFORMES

FAMILY ALCEDINIDAE

10. White- collared Kingfisher. *Halcyon chloris albicilla* Dumont. The first sight of the kingfisher was confusing because this bird so kingfisher-like as they are known here in the United States, was always seen on the highlands either in the trees or on telephone lines, but never in an area likely to possess fish as a diet. Finally a chance for observation presented itself so that with field glasses a typical specimen with a distinctly large, broad, blue-black bill possessing an orange shade to the mandible, could be noted. The metallic blackness of the bill extended back through the eye and around to the rear of the neck as a distinct narrow band. All the rest of the head, the neck, the breast and belly, were white and the feet dark. The back, wings, and tail contrasted in brilliant metallic blue-green that shimmered when they flew after an insect or another kingfisher. I would judge its total length to be six to eight inches from the huge bill to the end of the small tail.

The kingfisher was present in nearly every area investigated, and was usually seen sitting on a telephone wire. One bird frequently perched on an old frame stand near the barracks about sun-

set time. He would wait patiently several minutes and then would suddenly swoop down on the ground to pick up insects. On another occasion I observed a kingfisher being annoyed by two White-eyes, but in spite of their concern the kingfisher was only interested in chance insects it could seize and was using a small tree (possibly previously claimed by the white-eyes) and stump as a taking off base. The kingfisher would then dart out in mid-air and pluck something up, fly catcher-like, but probably was snatching something from a spider's web. These observations of food getting explained why the kingfishers were never seen around a lake or pool, hunting fish; they were strictly insect eaters. We always saw these birds along Broadway settled on the telephone lines. They usually appeared in pairs or singly, although one late afternoon there were four in an extended row, assuming a rather odd position. Each bird was sitting with wings half raised and the beak pointed up in a nearly vertical position. They were all in this situation for no apparent reason for it was not raining, nor was it excessively warm. In this same mood of odd performance about four of these raucous birds were seen gyrating through the air in desperate flight, one after one another, and creating a terrific din. They swooped, turned, and called out in shrieks and in rasping "click click" or the longer "sprrackit". We also heard them with considerable aversion early each morning just outside our barracks.

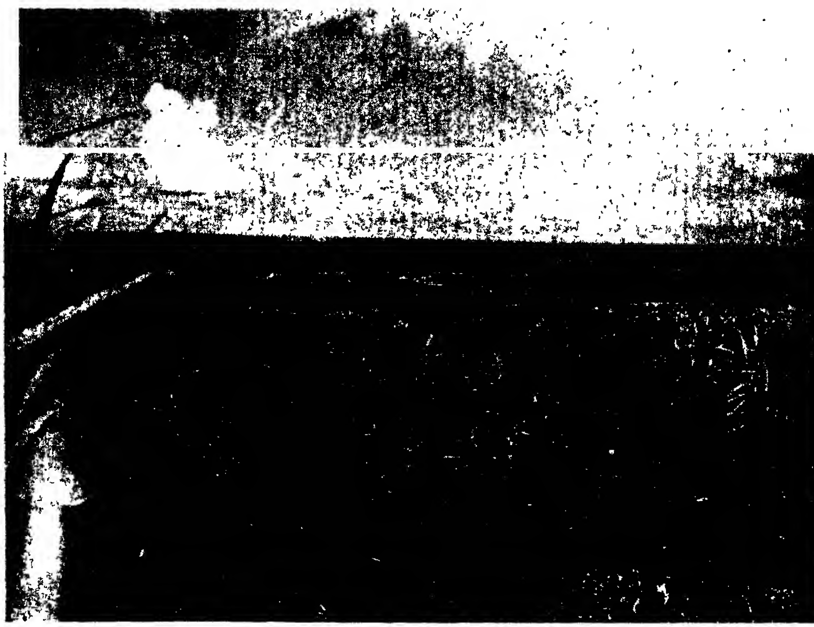
Mayr (1945 p. 295) and Peters (1945 p. 210) have given the limit of distribution of this species as Saipan and Tinian.

ORDER PASSERIIFORMES

FAMILY MUSCICAPIDAE

11. Rufous-fronted Fantail. *Rhipidura rufifrons* group. I was unable to ascertain any subspecific characteristics, but in all probability this was *Rhipidura rufifrons saipanensis* Hartert and it was by far the most colorful bird observed. September 7th was the date of our first observation, occurring in the vicinity of tall papayas adjacent to the lake area. It was not an extended observation, nor very leisurely because the two fantails persisted in moving rapidly from tree to tree, or darting out from the branches after an insect. Their body proportions were relatively small and nearly the same as the monarchs described later. Their most obvious features were the rufous rump and the flash of the white lower throat in contrast to the dark buff of the neck. Across the forehead was another rich rufous patch, slightly white in front of the eyes and at the base of the bill were small whisker-like feathers. The

wings were dusky brown and the tail rather noteworthy in its flashy twitching and display of the large round tip with white edges. On October 12th, the day of a second opportunity to watch the bird, I thought a blue cast to the beautifully speckled breast could be distinguished; formerly I had seen them as simply black specks. I also detected an exaggerated strut as one bird puffed its throat, flashed the white forehead and spread the pure white fringe on the broadly fanning tail. It was a very short display, but judging from this



Common sugar cane in foreground and distant view of the typically flat terrain.

small bit of study I presume it to be good evidence for verification of the name, fantail, together with its obvious rufous front.

Both observations of fantails took place on bright sunny days and at two extreme localities of the island; the second appearance being at the edge of the narrow side road over the hills at the south end of the Island (No. 11). It was a spot densely covered with the cool shade of the fern-like trees. It was here I also found the Tinian Monarch and numerous Bridled White-eyes.

Once or twice I was certain I saw the fantails snatch insects from the air and it seemed that their tremendous expenditures of energy was always directed toward the search for food from one

forested spot to the other. They seemed much less interested in humans than their close relative the monarch.

It would be difficult to attempt to describe the song of this bird. In my notes I made reference to an observation of "a beautiful rolling whistle, starting rather shrilly, then rolling on. Something like a meadow-lark and song sparrow combined." At least one can assume it was melodious and complete in its melody.

12. Tinian Island Monarch. *Monarcha takatsukasae* Yamashina. One specimen of this species was acquired, and again Mayr (1945 p. 296) was the only confirming reference available, and it definitely upheld the previous identification. The distinctive markings were easily detected with a specimen at hand. The one adult taken was a female; however, in the field the male and female were not distinguishable. The ovary in this female specimen was well developed. The total length of this bird was 140 millimeters, bill 14 millimeters, and tail 65 millimeters; the bill was black with many fine rictal hairs; the iris of the eye black; the crown blackish-gray-brown extending through the neck, the venter gradually fading to white on the vent. The under surface of the tail was lightly tinted with brownish-red shading to darker but this appearance abruptly changed to the flashy white tips that came into view when the bird quickly turned about. The wings consistently displayed the two white bars on the secondaries, against the all over gray-brown of the rest of the feathers. In the field this bird is rather subdued and drab in general appearance, yet on close observation its finish of soft colors and delicate build and movements add beauty to its appearance. A young bird was observed on September 8th—it was as large as the adult nearby, but more dull colored and presented the mottled, partially downy feathering of an immature bird. It had acquired the darkness of the upper feathers of an adult, and slight ventral buff coloring. It chattered ninety per cent of the time, fluttering from one branch to another and apparently was still partially dependent on the adult.

When these birds were first seen on June 7th at the north end of the island my impression was that they looked and behaved like small towhees; but a few days following this surmise, it was decided they must have been some kind of thrush, because they were so constantly flashing the white fringed tail. At a much later date, a "peeo-whirl" was heard to come dolefully from one's throat, and it was seen to dart for an insect. A few of the hairlike feathers at the base of the beak were noticed. It is not the common habit

for the bird to catch its food in mid-air because it prefers to shift rapidly over the surface of the leaves and branches in search of food, a procedure frequently witnessed. When in flight the bird would ascend and descend in rhythmic waves then slip under some foliage. With regard to its voice most of the time only the sad "peeo-whirl" whistle was distinguished (repeated once or twice) and thus the presence of the bird could be detected long before it was seen. Occasionally the monarch varied this note with an added warble or roll and a brief catch to it, and much of the time, when particularly disturbed by our presence, the monarch would sputter a constant "yyaatchit" or buzzing "eewheuzzz eewheuzzz", terminating in a sharp click.

Most frequently these birds were found in pairs, but once or twice as many as four were seen at one period of time. The localities were rather definitely placed in separate sections of the Island. The first record was made at the extreme north tip, area No. 1. The other findings were at Hagoi Lake, area No. 4, and at the south end of the Island beneath the cover of the trees along a favorite side road in the upland forest, No. 11. They clung to the mid-branches of the various trees and bushes on the island and preferred to stay within the forest boundaries, except in that one brief instance one was observed feeding high up on the side of the cliff, No. 4, among the heavy vines and roots.

On August 31, Sgt. Cypert was the first to discover the Monarch's nest about fifty yards distance within the forest along Hagoi Lake on the east side. The nest was about three feet from the ground carefully woven into the framework of a triangular crotch. It was a very small, sparsely foliaged bush with practically no protection as far as concealment was concerned, and composed exteriorly of small leaves, scattered white feathers, and heavy grass; interiorly of grasses only. The skeletal veined structure of the leaves remained, serving as meshed outer framework material for use in the construction of the entire nest. It measured about two and three quarters inches in outside diameter and three inches in outside depth. Inside the nest we found a young bird that quite comfortably filled it; a creature that was black-skinned, with ugly white quills and a few short dark feathers on its tail and wings. The back feathers were rusty brown as were the tufted head feathers. The adults did not approach the nest during our presence, but instead remained in the background, quietly watching our movements. The young bird lay perfectly still.

On September 1, the adults again refrained from approaching during my presence. This visit was short and not till the next day was there more activity noticed. These visits were all made at approximately 4:00 p.m. On September 2, I sat down about thirty feet from the nest, and this time the adults were much more aggressive and approached within ten feet of my post. They did not go near the nest, however, but seemed to be more concerned with feeding themselves and gradually my presence became ignored. I left the area for about thirty minutes, and on returning, one adult was found bringing food for the crying young one. The other adult seemed to be disinterested. Within ten minutes the active adult was seen to bring food twice. The second item appeared to be a green locust. The young one stretched its beak straight up with its scrawny head projecting about two inches above the edge of the nest and very little disturbance was caused, although the insect was a large one, about two inches long. It was at this time that the adults demonstrated some ability in snatching insects from the air during the execution of various whirls and loops. They seemed to obtain about one per minute.

On September 3, another visit was made to see the nest and this time some drastic measures had to be considered. A friend had warned that he had seen some men around the nest and was afraid if left too long it might be destroyed. As there was this possibility that it would be destroyed, it was decided to try to knock a bird down with a sling shot. It was nearly 4:30 p.m., raining, and little time at hand, and about ten or twelve shots were missed before a pebble finally happened to hit. Upon coming close to their nest the adults became greatly excited, keeping up a perpetual "yyatchet" or "eewheuzzz" and darting from one branch to the other, daring to come within eight or ten feet when I stood by the nest. The successful shot from a distance of fifteen feet had broken the bird's leg. The young bird was removed and the small bush holding the nest was cut. The other adult continued its attack as the job was being completed, but when I left and stepped away from the site, the male had become calmed and was whistling its usual call note—"Peeo-whirl". On various return visits to that spot no monarchs were seen.

If these birds' haunts are approached quietly and under cover they frequently become very curious and slip up closely to look one over. At site No. 11, they were very friendly while under the security of the fuller foliage, coming within a distance of two or three

feet on hearing the hand sucking squeak, then rather quickly they would fly away.

FAMILY STURNIDAE

13. MICRONESIAN STARLING. *Aplonis opacus guami* Momyiama. This race is listed by Mayr (1945 p. 297) as occurring on Guam, Rota, Tinian, Saipan, Southern Marianas, and is not well defined in these areas. On Tinian it was a bird not as common as the White-eye, but usually one or two were seen on each trip. It took some time to identify the bird because it possessed so many conflicting characteristics. At first, it was considered a black bird because of its over all black coloring, but it walked and continuously whistled and mimicked like a starling. The bill was thick, slightly curved and jet black, and the iris yellow. There were no spots on the breast, and the only birds that varied from this description were the immatures in their more somber and slightly streaked breast and back. This reference to coloration does not agree with Mayr's description of the immature birds on Guam. The starlings flew in a rather awkward ready-to-land-position. They were quite curious when hand squeaking was employed, which usually attracted four or five of them. However, they would not come close but continued their chatter which sounded something like a rusty wheel on a cistern or just a mimicking warble, a roll or shrill whistle.

These starlings were not abundant but were common and seemed to be confined to the wooded sections, especially Hagoi Lake. They enjoyed the higher trees as a habitat and were seldom seen in the open fields or on the ground. It was surprising to discover some of them concentrated near the small holes and caves of the cliffs in area No. 4, where the terns were so active. (It should be understood incidentally, that it was considered poor judgment to investigate these cliffs, because men had been killed by straggling Japs still hiding out, consequently our observations were made from the roadside with field glasses.)

FAMILY MELIPHAGIDAE

14. CARDINAL HONEY-EATER. *Myzomela cardinalis* group. In spite of the fact that this bird was seen but once its characteristic markings were easily recognized. It appeared at first to be similar to the Tanager; then the long curved bill was detected suggesting that it was a honey eater. This observation was on June 8, soon after my arrival on Tinian on an early morning excursion conducted in the wooded section just north of our tents (No. 1). It was less than three or four hundred yards to the sea shore, but the wood–

land enclosed the spot in an orchard-like atmosphere, and it was here a pair of these honey eaters ventured by. The male was chasing the rather drab female; in fact, it was this "romantic" activity that took them off and away so quickly. The male was very brilliant in its deep red coloring, offset with the black-brown wings, back, and tail. The eyes were dark, also the bill, and the rest of the body was a brilliant red. The neck seemed to be unusually long, and the head rather flat. Normally it stood upright with tail pointed down. The coloring of the female was in contrast dull and generally drab brownish. My attention was centered chiefly on the male for the brief period they were observed. Subspecific characters were undetermined, but geographically this Honey Eater is designated *Myzomela cardinalis saffordi* Wetmore, according to Mayr (1945 p. 299).

FAMILY ZOSTEROPIDAE

15. Bridled White-eye. *Zosterops conspicillata saipani* Dubois. The White-eyes were the first birds noticed on the island, and they later appeared to be the most abundant passerine bird. Mayr (1945 p. 299) specifies Saipan and Tinian as localiites of *Zosterops conspicillata saipani* Dubois, and the identifying marks correlate with his information. The *Zosterops* was the smallest bird seen; measuring approximately four inches in length. Its general coloring and form suggested a resemblance to our white-eyed vireo but was much smaller, habitually noisier and more gregarious. It was quite easy to distinguish the rather large white eye ring encircling the small black eyes, the short, pointed, brownish bill, the soft olive-green back and wings, (with no sign of wing bars) and a soft yellow tinge from the throat through the belly and vent. The tail was short, square and had the same shade of olive green as the back; lastly the feet were black and quite small. Its general movements and flight were similar to the noisy nervousness of English sparrows and its constant chirp was very much like the familiar sparrow note. (There were usually two birds together and much of the time six or seven.) On a single trip as many as twenty-six were distributed throughout the area traveled; however, due to the fact they never seem to stay in one spot, we could not be certain there was not some double counting. Normally, however, we found about two and much of the time, six or seven in a group. These little birds were quite responsive to hand squeaking, and would often come close to see what the cause could be, and it was then frequent attempts were made to hit one with a sling shot pellet, with no success, as was the usual custom.

Most of the time they were eating and unaware of intruders as they seemed to be picking food from the many cracks and crevices of the foliage. Once I definitely saw a White-eye eating a large green fuzzy caterpillar. The type of environment they seemed to favor was low brush or trees and the edges of open fields, but we encountered White-eyes at all sections of the Island. No other song than the "chirp, chirp" was heard which they uttered on the rise and fall of their choppy flight or when perched upon the summit of some low trees.

These little birds became so frequent on these trips that they began to be regarded as common as our sparrows are at home, except that in habitat selection the White-eyes definitely preferred some type of foliage. Their great abundance could be accounted for by the tremendous amount of insect life available on the Island.

III. POSSIBLE IDENTIFICATIONS

It should be emphasized again that the names used in this article were based strictly on field observations compared with material in Mayr's handbook, and those verifications were accomplished while actually on the Island. It is certainly possible that a rare subspecies might have been unrecognized.

There were three other birds observed on the islands but positive identifications were not possible. Later through use of references a decision was suggested as to their identity; however, they are listed as probable observations and are not considered otherwise.

1. Edible Nest Swiftlet. *Collocalia inexpectata* group. Two distant observations of probably *Collocalia inexpecta bartschi* Mearns.

2. Mongolian Dotterel. *Charadrius mongolus* group. One observation with a sketch.

3. Turnstone. *Arenaria interpres group.* Only one observation with a sketch was made. Numbers two and three were along the sea shore on September 23, and were probably visitors in migration.

IV. CONCLUSION

The bird population on Tinian appeared to be moderate in quantity and variety with a greater abundance of Philippine Doves and Bridled White-eyes as compared with other species noted. Military activity and construction had eliminated many natural habitats. Possibly the future holds a chance for return to a natural environment

for bird life as military operations gradually become less prevalent, and the Island returns to normalcy.

In spite of the fact that bird life was overshadowed in the presence of man's activity, a great deal of satisfaction resulted from the various excursions made. The greatest pleasure was to visit Hagoi Lake, a spot seemingly isolated from military activity, much like a miniature sanctuary; not only for birds, but for lizards, toads, a few fish, plants of various types and many insects. The opportunity for observation of the eighteen kinds of birds discussed in this paper was reason enough to declare that the short tour of duty on Tinian was actually a pleasant one.

BIBLIOGRAPHY

Hartert, Ernst, 1898, On the Birds of the Marianne Islands. Novitates Zoologicae, Vol. V, p. 51-69.
Gleize, Daniel A., 1945, Birds of Tinian. The Bull. of the Mass. Aud. Soc. Vol. XXIX, No. 7, Oct. p. 220.
Mayr, Ernst, 1945, Birds of the Southwest Pacific. The Macmillan Co., New York, N. Y. pp. i-xx, 1-316; 3 pls.; 16 figs.
Osborn, Fairfield, 1944, The Pacific World. W. W. Norton & Company, Inc., New York, N. Y., pp. i-xiii, 1-164.
Peters, James Lee, 1931, Check-List of Birds of the World. Harvard University Press. Vol. I, pp. i-xviii, 1-345.
——— 1934, ibid., Vol. 2, pp. i-xvii, 1-401.
——— 1937, ibid., Vol. 3, pp. i-xiii, 1-311.
——— 1940, ibid., Vol. 4, pp. i-xii, 1-291.
——— 1945, ibid., Vol. 5, pp. i-xi, 1-306.
Wetmore, Alexander, 1940. A Systematic Classification for the Birds of the World. Smithsonian Miscellaneous Collections, Vol. 99, October 10, Number 7, Pub. 3592, pp. 1-11.

Botanical Notes: 1945

FRANK U. G. AGRELIUS
Kansas State Teachers College, Emporia

"The Unusual Is Usual in Kansas" and this year has illustrated this truth again. In addition to the unusual seasonal activities, we note several items.

Fruits of the American Elm (*Ulmus americana*) were probably the most abundant ever noted by us. This resulted in a large crop of young elm trees which complicated the care of gardens. It is probable that this occasional habit has been an important factor in extending forested areas in Kansas when suitable conditions have permitted.

Trifolium repens appeared in unusually large proportions in our lawn. What we understand as out of the ordinary was the appearance of several ripe fruits in our Lily-of-the-Valley (*Convallaria majalis*) plants. The percentage of bearing ones was quite small.

Among the unusual objects were two fungi. One was a tiny agaric, *Psathyrella disseminata* Pers., and a puffball, *Calvatia rubroflava* (Cragin) Lloyd. The former was noticeable for its small size, the latter for its decided yellow or orange color. Both of these appeared in our garden and I have never observed them elsewhere.

We made pictures of two Hollyhock plants that grew in what seemed to be ordinary garden soil. The taller of these was eleven feet, seven inches in height.

What appeared to us as the most striking phenomenon of the year was a plant of *Liatris punctata*, a member of the great composite family, in which the carpellate number is definitely fixed at two. Nevertheless, the many flowers of the long spike each possessed a three parted stigma. Furthermore this was a wild specimen and had not been subjected to the influences of cultivation and domestication.

A peculiar coincidence was the fact that a hard freeze occurred on November 21, as happened in 1944. This too stopped most of the visible plant activities.

The following table shows the dates of unusual behavior noted during 1945. Most of these are the latest time of blooming. The

Transactions Kansas Academy of Science, Vol. 49, No. 1, 1946.

first listed is the exceptionally early time of the formation of pollen in the plant named.

Juniperus virginiana	Sept. 24
Tradescantia reflexa	Sept. 6
Allium stellatum	Sept. 2
Aquilegia latiuscula	July 21
Philadelphus coronarius var. virginalis	Sept. 5
Hydrangea paniculata	Sept. 6
Spiraea van houghtii	Aug. 28
Pyrus japonica Chaenomeles lagenaria	Dec. 1
Rosa rugosa (white)	Aug. 30
Rosa sp.	July 19
Aesculus glabra	Sept. 14
Althaea rosea	Sept. 24
Oenothera speciosa	Sept. 2
Oenothera missouriensis	July 29
Syringa vulgaris	Nov. 2
Ipomoea sp. ("Heavenly blue")	Nov. 7
Physostegia virginiana	Nov. 20
Lycopersicon esculentum (Ripening fruit)	Nov. 1
Houstonia angustifolia (Both forms)	Sept. 2
Weigela rosea (W. florida in Stand. Plant Names II)	Aug. 14
Chrysanthemum leucanthemum	Oct. 26
Taraxacum officinale	Nov. 1

Fields of Activity for State Academies of Science

Dr. John C. Frazier, Academy representative at the meeting of the American Association for the Advancement of Science in St. Louis, presented at the Emporia meeting of the Academy, the report of the A.A.A.S. committee on possibilities of improving senior academies of science. The committee, which included Dr. R. C. Smith of Kansas State College, Manhattan, has outlined the suggestions given below for state academy activities. Although obviously incomplete, as compared to some of the activities now under way in our own Academy, some of the committee's suggestions should prove valuable in enhancing the possibilities of the Academy's usefulness.

COMMITTEE REPORT

I. Internal activities.

A. The annual meeting and program. As an established feature of academy activity these meetings seem to be valuable:

1. In establishing and maintaining contact among scientists of neighboring institutions, probably more broadly and effectively than national organizations.
2. In providing for the exchange of original researches in fields of limited geographic scope.
3. In affording an opportunity for the presentation of minor contributions which may not be available for the programs of national organizations.
4. Possibly the most important function of these meetings and their programs is to extend to younger scientists the advantages that they might gain much more slowly in national organizations.

B. Establishment of research funds:
   1. To meet minor needs which might not receive support from national funds.
   2. To lend encouragement to younger scientists who may lack the support needed to secure grants from funds administered from more distant centers.

II. Sponsorship of junior academies.
   A. Personal interest of academy members in junior academies is apparently very limited. It should be extended, since it is a valuable encouragement to prospective scientists.
   B. Concrete measures to support junior academies, in the form of awards such as prizes or certificates for participation in public programs have been shown to possess considerable value.
   C. Affiliation with the Science Clubs of America is evidently a source of aids of various kinds in the scientific work of secondary schools.

III. Public service projects.
   A. The perpetuation of natural areas in the form of public parks and preserves.
   B. An appraisal of the resources of the state in which the academy is located and aid in their development.
   C. Reclamation projects.
      1. Reforestation of waste lands in originally forested areas.
      2. Return of unpromising cultivated areas to grasslands in the prairie and plains states.
      3. Restriction of damaging influences, such as pollution of streams, strip mining and methods of cultivation resulting in excessive erosion.

IV. Industrial research.
   A. Provision of a medium of exchange between industrial organizations and scientists in the adjoining area.
      1. Means of acquainting industry with available scientists for special projects or employment, part or full time.
      2. Means of opening opportunities for practical scientific work to members.
      3. Means of breaking down barriers between industrial and academic fields.
   B. Augmentation of research funds.
      1. By direct contributions.
      2. Through institutional memberships.

The Seventy-Eighth Annual Meeting

The seventy-eighth annual meeting of the Kansas Academy of Science was held at Kansas State Teachers College, Emporia, Kansas on April 11, 12 and 13, 1946, with Dr. John W. Breukelman, professor of biology of the College, presiding. The Kansas Entomological Society, which is affiliated with the Academy, held its twenty-second annual meeting on April 13. The following other state societies held their meetings in cooperation with the Academy: The Kansas Association of Teachers of Mathematics, the Kansas chapter of the Mathematical Association of America, and the Kansas chapter of the American Association of University Professors.

This was the first three day meeting since 1942. Three hundred and twenty-four members of the Senior Academy registered and an estimated attendance of 250 was reported for the Junior Academy. The Academy program opened Thursday evening with a lecture entitled, "Kansas Wild Plants as Sources of Industrial Raw Materials," by Dr. John R. Clopton, chief chemist, Kansas Research and Management Company and associate professor of physical science, Kansas State Teachers College, Emporia. Sectional meetings were held on Friday and Saturday. A new section on industrial psychology and personnel met Saturday morning with Dr. J. C. Peterson of Kansas State College as chairman. The reports of the section chairmen are presented herewith in Table 1.

TABLE 1.

Name of Section or Organization	Chairman for 1946	Number of Papers Given	Number Attending	Chairman for 1947
Botany	C. F. Gladfelter	10	30	O. R. Clark
Chemistry	Ruth Thompson	9	34	O. W. Chapman
Geology	John C. Frye	16	39	J. M. Jewett
Industrial Psychology and Personnel	J. C. Peterson	6	23	J. A. Coleman
Kansas Entomological Society	H. H. Walkden		48	J. C. Frankenfeld
Kan. Chap. Math. Assoc. of America	Edison Greer	5	46	C. A. Reagan
Kan. Assoc. Teachers of Math.	Helen R. Garman	3	150	Mrs. Lottchen Hunter
Physics	G. W. Matthews	4	42	J. D. Stranathan
Psychology	J. A. Glaze	10	37	J. C. Coleman
Science Teachers	Blaine E. Sites	5	35	Guy B. Homman
Zoology	Mary E. Larson	19	50	Donald Farner
Junior Academy	Edith Beach		250	Ralph Rogers

The invitational address entitled "The Scientist's Increasing Social Responsibility" was given by E. Finley Carter, vice-president of the Sylvania Electrical Products Co., at 11:00 a.m., Friday, before a combined College and Academy assembly. The annual banquet was held Friday evening with the newly installed president, Dr.

Claude W. Hibbard of the University of Kansas, presiding as toastmaster. Prof. Frank Agrelius of Kansas State Teachers College, Emporia gave a brief account of his association with Dr. L. C. Wooster, the Academy's oldest living member who was unable to attend because of illness. Dr. John W. Breukelman as retiring president gave an address entitled "Review of Kansas Ichthyology."

The following officers were elected for next year: President, Dr. Claude W. Hibbard, University of Kansas; President-elect, Dr. J. C. Peterson, Kansas State College; Vice-president, Dr. F. W. Albertson, Fort Hays Kansas State College; Secretary, Dr. S. M. Pady, Kansas State College; Treasurer, Prof. S. V. Dalton, Fort Hays Kansas State College; additional executive council members, Dr. J. W. Breukelman, Emporia; Dr. Paul G. Murphy, Pittsburg; Dr. P. S. Albright, Wichita; Ralph Rogers, Manhattan High School (chairman of Junior Academy for three years). Dr. W. J. Baumgartner, of the University of Kansas, was reelected managing editor. Dr. Paul Murphy, Pittsburg, was elected associate editor for a term of three years. Dr. D. J. Ameel, Kansas State College, was elected Academy librarian.

The official program is given below.

DONALD J. AMEEL, *Secretary.*

THURSDAY, APRIL 11

4:00 p.m. Executive Council Meeting.
5:00 p.m. to 9:30 p.m. Registration.
7:30 p.m. Public Lecture, "Kansas Wild Plants as Sources of Industrial Raw Materials," by John R. Clopton, Chief Chemist, Kansas Research and Management Company, Associate Professor of Physical Science, Kansas State Teachers College, Emporia, Kansas.
9:00 p.m. General Reception, Student Union Building.

FRIDAY, APRIL 12

8:00 a.m. Registration.
9:00 a.m. to 10:00 a.m. Sectional Meetings.
10:10 a.m. to 10:45 a.m. Business Meeting, President Breukelman, presiding.
1. Announcements.
2. Brief reports of the recipients of the 1945 Research Awards.
3. Reports of Academy Officers.

11:00 a.m. Public Address, "The Scientist's Increasing Social Responsibility," by E. Finley Carter, vice-president, Sylvania Electrical Products, Incorp., New York City, N. Y.
12:15 p.m. Lunch
1:30 p.m. Sectional Meetings.
Botany, 108 Norton Science Hall.
Chemistry, 102 Norton Science Hall.
Geology, 207 Norton Science Hall.
Junior Academy, 104 Norton Science Hall.
Physics, 202 Norton Science Hall.
Psychology, 208 Administration Building.
Zoology, 5 Norton Science Hall.

3:30 p.m. to 6:00 p.m. Registration for Entomology, Mathematics, and The American Association of University Professors. Norton Science Hall.

6:30 p.m. Academy Banquet, Masonic Temple Dining Room. Toastmaster: Claude W. Hibbard, Dyche Museum, University of Kansas, Lawrence, Kansas.

Address of Welcome, David L. MacFarlane, President, Kansas State Teachers College, Emporia, Kansas.

Presidential Address: "Review of Kansas Ichthyology," by John Breukelman, Professor of Biology, Kansas State Teachers College, Emporia, Kansas.

SATURDAY, APRIL 13

8:30 a.m. to 9:30 a.m. Business Meeting, 5 Norton Science Hall.

9:30 a.m. to 12:00 noon. Sectional and Affiliated Meetings.
Science Teachers, 108 Norton Science Hall.
Botany and Zoology, 5 Norton Science Hall.
Entomology, 104 Norton Science Hall.
Mathematics, Music Hall Auditorium.
Geology Field Trip. Time and place to be announced.

12:15 p.m. Luncheon Meeting of 1946 Council, Student Union Building.

1:30 p.m. Affiliated Meetings.
Entomology.
Kansas Association of Mathematics Teachers.
The Mathematical Association of America.
The American Association of University Professors.

* * *

KANSAS CHAPTERS
AMERICAN ASSOCIATION OF UNIVERSITY PROFESSORS

C. M. Correll, Kansas State College, Manhattan, presiding

SATURDAY, APRIL 13

Reorganization discussion.

* * *

SCIENCE TEACHERS

Chairman, Blaine E. Sites

SATURDAY, APRIL 13

1. Laboratory Technique adapted to H. S. students. W. E. Simpson, Salina High School.
2. Effect of Nuclear Energy Developments on Classical Teaching of Physics. A. B. Cardwell, Kansas State College.
3. College Entrance Credit for Students who have had H. S. chemistry. Roy Rankin, Ft. Hays Kan. St. College.
4. Radar, and its contribution to the future. S. W. Cram, Emporia Teachers College.
5. Color Photography as an aid in Teaching Biology in High School. Andrew Riegel, Ft. Hays Kan. St. College.

* * *

BOTANY

Chairman, C. F. Gladfelter

FRIDAY, APRIL 12

1. Botanical Notes for 1945. F. U. G. Agrelius, K.S.T.C., Emporia. 5 min.
2. Kansas Botanical Notes for 1945. Frank C. Gates, K.S.C. 5 min.

3. Forage Yields (1945) of Various Native Grasses Established Artificially at Hays, Kansas in 1941. Andrew Riegel, F.H.K.S.C., Hays. 10 min.
4. Tannin Content of Sumac under Various Environmental Conditions. Ivan L. Boyd, Baker U., Baldwin. 8 min.
5. Histoplasmosis. Clinton C. McDonald, U. of Wichita, Wichita. 5 min.
6. Milkweed Floss Collection in Kansas. C. F. Gladfelter, K.S.T.C., Emporia. 10 min.
7. Flora of Clay Co., Mo. I. Flowering plants. L. J. Gier and Wanda Ponder, William Jewell College, Liberty, Mo. 5 min.
8. Mycological Notes for 1945. S. M. Pady and C. O. Johnston, K.S.C. Lantern. 5 min.
9. Teliospore Development and Germination in Melampsorella. S. M. Pady, K.S.C. Lantern. 6 min.
10. Note on the Occurrence of some Eastern Wisconsin Plants. Charles G. Schoewe, Milwaukee, Wisconsin. (By title) 5 min.

* * *

CHEMISTRY

Chairman, D. Ruth Thompson

FRIDAY, APRIL 12

1. Chemistry Courses for Student Nurses Offered in Kansas Colleges. Sister Mary Grace Waring, Marymount College. 8 min.
2. The Response of Different Photometers to the Color Produced by Vitamin A and Carotene with Antimony Trichloride. M. J. Caldwell, D. B. Parrish and W. G. Schrenk, K.A.E.S., Manhattan. Lantern. 10 min.
3. The Use of Nitroparaffins in the Skraup Synthesis. Glenn Stevenson and Ray Q. Brewster, K. U. Lantern. 10 min.
4. A study of Mercury-in-Oil Emulsions. Amos L. Lingard and Robert Taft, Sr., K.U. Lantern. 10 min.
5. The Status of Municipal Water Softening in Kansas. Roy Rankin, F.H.K.S.C., Hays. 5 min.
6. Anodic Oxidation of Gallium in Acetic Acid Solution. Frank Jirik and Arthur W. Davidson, K.U. 10 min.
7. Variable Valence Number. Harry Sisler, K.U. 15 min
8. The Present Status of the Drug Dicumarol. Donald C. Brodie. K.U. 10 min.
9. Application of the Electronic Theory to Some Simple Organic Reactions. II. Calvin A. Vander Werf, K.U. (By Title).

* * *

GEOLOGY

Chairman, John C. Frye

FRIDAY, APRIL 12

1. Geologic Structure Near Manhattan, Kansas. Vincent Bruce Coombs, K.S.C., Lantern. 10 min.
2. Chemical Quality of Ground Water in Arkansas Valley in Central and Southern Kansas. Charles C. Williams, Federal and State Geological Surveys, Lawrence. Lantern. 10 min.
3. Petrography of Silicified Rocks in the Ogallala Formation in Western Kansas. Ada Swineford, State Geological Survey, K.U. Lantern. 10 min.
4. The Mining of Permian Coal in Kansas. W. H. Schoewe, State Geol. Survey, K.U. 10 min.
5. Geology of the Big Marsh Area, Stafford County, Kansas. Bruce F. Latta, Federal and State Geological Surveys, Lawrence. Lantern. 10 min.
6. Fossilized Heart. D. C. Schaffner, C. of E., Emporia. Lantern. 5 min.
7. *Trematapis wimani*, n. sp., from the Upper Silurian of Oesel. George M. Robertson, F.H.K.S.C., Hays. Lantern. 10 min.
8. The Cragin Quarry Faunule. Claude W. Hibbard, K.U. Lantern. 10 min.

9. Pennsylvania Plant Fossils Found on the Campus of Baker University, Baldwin, Kansas. Arthur Bridwell, Baker U. Lantern. 10 min.
10. Convergence of the Interval Between the Stanton and Plattsburg Limestones, Wilson County, Kansas. Virgil Burgat and J. R. Chelikowsky, State Hwy. Dept., and K.S.C. Lantern. 10 min.
11. Permian Cycles in West Texas. Frank Byrne, K.S.C. Lantern. 10 min.
12. Mississippian Stratigraphy of Southwestern New Mexico. L. R. Laudon, K.U. Lantern. 15 min.
13. The High Plains Surface in Kansas. John C. Frye, State Geological Survey, K.U. Lantern. 10 min.
14. Survey of the Fossil Vertebrates of Kansas: Part III, The Reptiles. H. H. Lane, K.U. (By title.)
15. Survey of the Fossil Vertebrates of Kansas: Part IV, The Birds. H. H. Lane, K.U. (By title.)
16. Survey of the Fossil Vertebrates of Kansas: Part V, The Mammals. H. H. Lane, K.U. (By title.)

FIELD TRIP

A Field trip in Cottonwood valley area, west of Emporia, was taken Saturday morning.

* * *

JUNIOR ACADEMY OF SCIENCE OF KANSAS

Chairman, Edith Beach, Lawrence

FRIDAY, APRIL 12

* * *

KANSAS ENTOMOLOGICAL SOCIETY

TWENTY-SECOND ANNUAL MEETING

H. H. Walkden, Pres.; P. B. Lawson, Vice-Pres.;
D. A. Wilbur, Sec. Treas.

SATURDAY, APRIL 13

1. Business meeting.
2. Presentation of papers.

Afternoon Session—1:30 p.m.

3. Entomological notes.
4. General discussion of selected entomological problems.

JOINT SESSION

MATHEMATICAL ASSOCIATION OF AMERICA

KANSAS SECTION

and

KANSAS ASSOCIATION OF TEACHERS OF MATHEMATICS

SATURDAY, APRIL 13

—Morning Session—

Joint Session, Kansas Association of Teachers of Mathematics and Kansas Section of Mathematical Association of America
Edison Greer, K. U., Presiding

1. Varying Definitions of Mathematical Terms. J. R. Hanna and C. B. Read, Wichita U.
2. Mathematics for Women. Sister M. Helen Sullivan, Mt. St. Scholastica College, Atchison.
3. Common Factors in College and H. S. Methods of Teaching Mathematics. J. O. Hassler, Oklahoma U., Norman, Oklahoma.
4. College Entrance Tests in Mathematics. W. T. Stratton, K.S.C., and E. B. Stouffer, K.U.
5. Business session of Kansas Association of Teachers of Mathematics. Helen R. Garman, Presiding.

—Afternoon Sessions—

Mathematical Association of America

Edison Greer, K.U., Presiding

1. Some Mathematical Considerations of Supersonic Flight. C. B. Tucker, K.S.T.C., Emporia.
2. Application of Mathematical Statistics to Agricultural Experimentation. H. C. Fryer, K.S.C.
3. Report on Board of Governors Meeting. G. W. Smith, K.U.
4. Business section.
5. General discussion. Freshmen Mathematics Courses.

Kansas Association of Teachers of Mathematics

Helen R. Garman, K.S.T.C., Emporia, Presiding.

1. An Accelerated Group in Junior High School Mathematics. Beula Royer.
2. Functional Geometry. J. O. Hassler, Oklahoma U., Norman, Oklahoma.
3. Light on Mathematics. A Moving Picture.

PHYSICS

Chairman, G. W. Matthews

1. A Revamped Laboratory Course in Electronics Based Upon Wartime Practices. Harvey A. Zinzer, F.H.K.S.C., Hays. 15 min.
2. Electron Flow as Current. S. W. Cram, K.S.T.C., Emporia. Lantern. 10 min.
3. A New Version of a Phase Shift Oscillator. L. K. Davis, K.S.T.C., Emporia. 10 min.
4. Physics on Various Levels in a Veterans Training Program, G. W. Matthews, K.S.T.C., Pittsburg. 15 min.

PSYCHOLOGY

Chairman, J. A. Glaze

FRIDAY, APRIL 12

1. Concept Formation as a Function of the Complexity of Stimuli. H. B. Read, F.H.K.S.C., Hays. Lantern. 15 min.
2. A State Service for the Study of Children. Bert A. Nash, K.U. 15 min.
3. Misconceptions of Behavior Amongst College Students. James C. Coleman, K.U. 15 min.

Afternoon Session, 1:30 p.m.

4. Possible Use of Entry Occupational Classification, Dictionary of Occupational Titles. Part IV. H. S. Counselors. Edw. W. Geldreich, K.S.T.C., Emporia. Lantern. 15 min.
5. Career Week—A Shotgun Method of Dispensing Occupational Information. Miss Frances M. Ross and Edw. W. Geldreich, K.S.T.C., Emporia. 10 min.
6. Problems Encountered in A Guidance Bureau. E. R. Roeber, Dir. Guid. Bureau, K.S.T.C., Pittsburg. 15 min.
7. Valuable Tests for Guidance Service. H. E. Schrammel, Bureau Ed. Meas., K.S.T.C., Emporia. 15 min.
8. K.S.T.C., Emporia, Norms of the Kuder Preference Record. Miss Marian L. Sanders, K.S.T.C., Emporia. 10 min.
9. An Examination of the Pupil Personnel Services of K.S.T.C., Emporia. Edw. W. Geldreich, K.S.T.C., Emporia. 15 min.
10. Interpreting Test Results to a Group of Seniors. W. I. Mueller, Dir. Guidance, St. John's Military School, Salina.
11. Business session.

INDUSTRIAL PSYCHOLOGY AND PERSONNEL

Chairman, J. C. Peterson

SATURDAY, APRIL 13

1. Where Theory and Practice Should Meet (Probs. Common to Educ. and Indust.) Francis Gregory, Wyandotte H. S., Kansas City. 10 min.
2. T.W.A.'s Industrial Training Program. R. C. Murray, Mgr., Training Centers, T.W.A., Kansas City, Mo. 15 min.
3. Comparison of the Scores of Design-Engineering Personnel with Factory Workers on the MacQuarrie Mechanical Performance Ability Tests. Irvin T. Schultz, Associated Personnel Technicians, Wichita. 15 min.
4. Hypomania Scores of Veterans on the Minnesota Multiphasic. J. F. Hesse, Associated Personnel Technicians, Wichita. 10 min.
5. A Study in the Use of the Strong Vocational Interest Blank as a Part of a Battery of Selection Tests. Bentley Barnabas, Associated Personnel Technicians, Wichita. 15 min.
6. The Function of Counseling in Personnel Work. M. D. Woolf, K.S.C., Manhattan. 15 min.

At 12:00 there was a luncheon followed by a forum for the discussion of problems in personnel management.

* * *

ZOOLOGY

Chairman, Mary E. Larson

FRIDAY, APRIL 12

1. Nesting Record of the Yellow-headed Blackbird in Kansas. H. W. Setzer and R. L. Montell, K.U. 5 min.
2. Birds on Tinian in the Marianas. Theodore Downs, K.U. Lantern. 8 min.
3. Description of *Elaphe quivira*, A New Rat-Snake from Kansas. Charles E. Burt, Topeka. 5 min.
4. Living and Fossil Pupillidae (Gastropoda) of the Sanborn Area, Northwestern Kansas. Dorothea S. Franzen, K.U. Lantern. 10 min.
5. Histological Study of Duodenum of White Rat. L. J. Gier, Wm. Jewell, Liberty, Mo. Lantern. 10 min.
6. Fauna of Clay County, Missouri, Amphibian and Reptile. L. J. Gier, Wm. Jewell, Liberty, Mo. 6 min.

Afternoon Session, 1:30 p.m.

7. Fatigue and Work Capacity of Muscles from Animals Treated with Male Sex Hormone. E. H. Herrick and Richard S. Storer, K.S.C. Lantern. 8 min.
8. Protein Supplements and Natural Resistance of Chickens to Parasitism. B. B. Riedel and J. E. Ackert, K.S.C. Lantern. 8 min.
9. Host Growth as a Factor in Resistance of Animals to Parasitism. J. E. Ackert, Dorothy S. Branson, and B. B. Riedel, K.S.C. Lantern. 8 min.
10. Effect of Fowl Ascarid Infections on Host Resistance to Bacterial Toxin. Dean S. Folse and J. E. Ackert, K.S.C. Lantern. 8 min.
11. Migration Records of Birds in Eastern Kansas. R. F. Miller and I. L. Boyd, Baker University. Lantern. 5 min.
12. Correlations of Organ Weights in the Adult Cat. Homer B. Latimer, K.U. Lantern. 10 min.
13. Mammals of Nevada. E. R. Hall, K.U. 10 min.
14. The Northward Spread of the Cotton Rat (Sigmodon) in Kansas. Donald F. Hoffmeister, K.U. Lantern. 10 min.
15. A Specimen of Horned Cottontail. George M. Robertson, Fort Hays, K.S.C. Lantern. 5 min.
16. Salamanders in the Collections of Kansas Institutions. (K.U. & Ottawa U.) M. Maldonado-Koerdell, K.U. 10 min.
17. Some Binomics of a Common Flea. *Ctenophthalmus pseudagyrtes* (Baker). E. W. Jameson, Jr., K.U. (By Title).
18. Myiasis in a Box Turtle, *Terrapene ornata*. D. J. Ameel, K.S.C. (By Title).
19. Why has the White-tailed Jack Rabbit Become Scarce in Kansas? H. Leo Brown, Mankato. (By Title.)

Transactions
Kansas Academy of Science

Volume 49, No. 2 September, 1946

How Lakes Came to Kansas

EDWIN O. STENE
Bureau of Government Research, University of Kansas, Lawrence.

Earth, air and water are fundamental human needs. Kansas has always had her share of good earth as well as a plenteous and never-failing supply of air. Not satisfied with these two requisites, popular and insistent demand by the people of the state has resulted in the building of over a hundred lakes in an originally lakeless state. We may expect even greater additions to the Kansas "seas" in the future as Dr. Stene points out in the interesting article which follows. For further information concerning the author of "How Lakes Came to Kansas" see page 139.—The Editor.

Kansas is remarkably deficient in natural water surface. Of her total area of 82,276 square miles only 163 square miles are covered by water.[1] Even this 163 square miles of water area consists chiefly of rivers, there being an almost complete absence of lakes within her borders. Several rivers flow across the state from east to west, but their waters proceed to the Missouri River or into other states without hesitating to spread over areas sufficiently large to be called lakes. The continuous and rather pronounced drop in altitude from the western border to the eastern probably is sufficient answer to the question of why the streams and rivers of Kansas, when they have water, "just keep rolling along".

Early in the state's history this absence of natural reservoirs, combined as it was with periods of low rainfall, led to official sponsorship of programs of impounding waters in ponds and reservoirs. The state board of agriculture sought to encourage farmers to build ponds in order to preserve water for their cattle, and the state fish commissioner published instructions and diagrams for the construction of farm ponds, largely with a view to increasing the fish resources of the state.[2] It was chiefly in these ponds that the commissioners sought to plant the German carp which were introduced into the state during the late nineteenth century.

However, the first major project to impound water in Kansas occurred in the last decade of the nineteenth century, when F. B. Koen, a wealthy Colorado rancher, undertook to flood a low area in Barton County by drawing water from the Arkansas River. The land in this area, known as Cheyenne Bottoms, was said to be unsuited for agricultural purposes. By flooding the Bottoms, Koen hoped to establish a lake which would serve not only as an attraction to waterfowl and fish, but also as a source of water supply for the irrigation of surrounding farm lands.(3)

Koen organized the Lake Koen Navigation and Reservoir Company and dug a ditch 40 feet wide and extending 14 miles from the Arkansas River to the Bottoms. But in the words of a newspaper editorial, "he never turned the water on".(4) About the time that the ditch was completed "land sharks came along and settled on some of the land in the basin". They saw the possibility of securing profitable compensation when the land was flooded. Koen made an appeal to the state legislature, and secured legal authority to condemn land under eminent domain for the lake project.(5) The necessity of purchasing the lands required extensive financing, however, and litigation before the courts delayed the program for many years. Although the main ditch was dug and a small part of the area flooded, the project as a whole was never completed. Within a short period the ditch was closed by sediment and land falls.

Meanwhile the frontiers of an earlier Kansas had disappeared and agricultural prices had risen above the low levels of the 1890's. Land settlement once more became a primary interest, and so, about fifteen years after the flooding and irrigation project had been undertaken, the Missouri Pacific Railroad announced a new plan to drain the Bottoms in order that the land might be farmed. Newspaper reports told of the excellent hunting grounds the swamps had been, but spoke effusively of the rich soil that would be opened up under the drainage project.(6) Thus the first cycle of flooding and draining projects was completed. After another twenty years, as will be seen, water and wild life once more were to be regarded as the most desirable asset in the Cheyenne Bottoms.

None of the early projects to impound water for recreational purposes was undertaken by the state. Farm ponds were recommended by state agencies, yet individual farmers were responsible for such ponds as were built. The legislature granted the right of eminent domain for the flooding of the Bottoms, but the project itself was a private undertaking. A few small lakes were built in

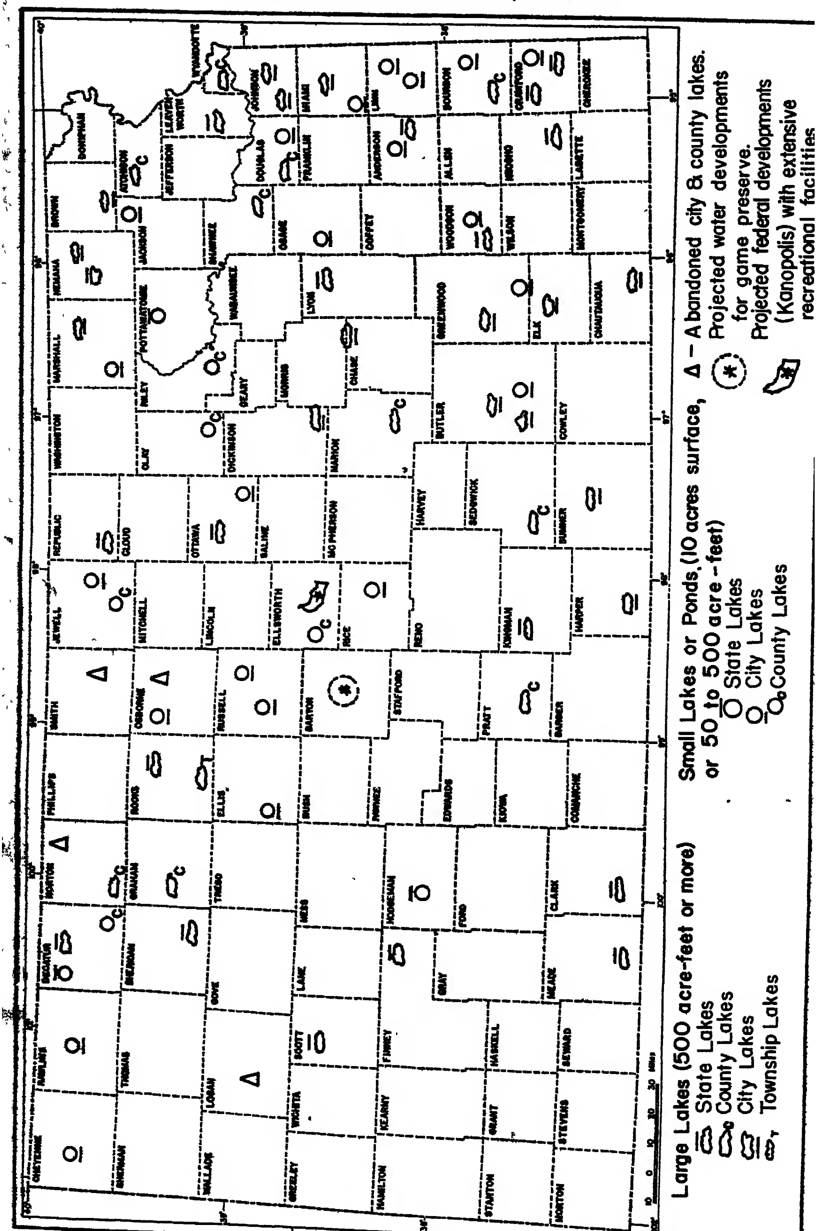


Fig 2. The Lakes of Kansas. Information secured since the map above was prepared shows the following additions or corrections: A city lake (Eskridge) should be shown for Wabaunsee County and a county lake for Ford County; both lakes shown for Anderson County are city lakes; one of the lakes shown for Butler County should be a state lake. For more detailed information see Tables I, II, and III.

various localities in the state for recreational purposes by sportsmen's clubs and private individuals. Railroad companies built dams to provide water reservoirs, and also in a few cases they developed the impounded waters into attractive lakes.[7] The possibilities of artificial lakes were becoming apparent. At the same time, the idea of restoring wild life by means of propagation was winning public support.

Money in Search of New Uses. Though it had given its official approval to private projects to impound water, the Kansas legislature did not display an interest in publicly financed projects until special funds for that use were actually in sight. These funds came into being through the enactment of a hunting license law and the enforcement activities of the state fish and game department. In 1905 the office of state fish and game warden was established through the consolidation of two exisiting agencies. Also in that year the legislature enacted a hunting license law. With the increased revenues obtained under this law, the state fish hatchery was established and developed, and programs for the propagation of upland wild birds were inaugurated. After 1920 the revenues from hunting licenses rose sharply, partly because of a new interest in the sport, partly because the establishment of a small force of full-time, salaried game wardens assured more effective enforcement of game laws than had been possible when the department was compelled to rely on unsalaried wardens. The department's funds began to accumulate. Yet the licensing of fishermen was in the making, not only because the hunters demanded equality of treatment, but also because the department considered a license system as necessary to effective regulation. With these prospects for enlarged revenues, the stage was set for a new program of expenditure.[8]

"A Lake in Every County." The development, as outlined above, was well under way in 1923 when Governor Davis appointed as his state fish and game warden a man who was not only an enthusiastic sportsman but also an imaginative leader and a capable writer and speaker. The new warden, J. B. Doze, had previously observed the farm pond programs of Warden Lewis Dyche and others; also he had organized a hunting club and constructed a dam for a small artificial lake. As warden he was anxious to build favorable public relations, especially with hunters and fishermen, and in all probability he was seeking a popular project with which to publicize the work of his department. Already the idea of state lakes had been suggested from various sources, especially by hunting and

fishing enthusiasts. Among those who dreamed of a public lake building program was Lee Larrabee, who later was to be appointed to the first forestry, fish and game commission and to become one of its most active members, and who is now chairman of the re-

MR. J. B. DOZE

organized commission.(9) Yet without doubt Warden Doze deserves the credit for initiating public interest in the possibilities of artificial lakes for Kansas.

Shortly after he became warden, Doze began to sponsor the organization of local fish and game associations. He encouraged these associations and city clubs as well to develop ponds. Nevertheless he was convinced early that small ponds would not fulfill the needs of the state. In public lectures and at meetings of associations, therefore, he began to spread the idea of artificial lakes, as sanctuaries for ducks and fish, as beauty spots and as water reservoirs. At his headquarters, Doze obtained a relief map of the entire state, and marked on it the locations of possible lake sites. He carried surveying instruments in his fish car, and made several investigations of sites at the request of local associations. Before the end of his first biennium in office he was advocating "a lake in every county", a slogan that was popularized by a gubernatorial candidate five years later.

Warden Doze's views on the lake program were summarized forcefully in the following excerpt, which is quoted from his first biennial report to the legislature (1924).[10]

ENLARGE WATER AREA

First of all in importance, if Kansas desires to increase its wild life, is to increase the water area of the state. By doing so we will build more homes for more wild-life population. Under present conditions Kansas cannot expect more than half the wild life of its neighbor on the south or half that of its neighboring state to the north.

The total water area of Kansas was, when surveyed, but 384 square miles. That probably is the maximum figure, and wild-life population must be considered from the minimum water area. Nebraska, a smaller state, has a water area of 712 square miles, while Oklahoma, with a total area of 12,000 square miles less that Kansas, has 643 square miles under water.

There is but one way to increase the water area of Kansas, and that is by impounding flood waters and turning a part of the water from never-failing streams into reservoirs. And there is but one agency to do this—the state. Heroic measures must be adopted, for the task is exceedingly large and entails the building of many dams, many days in the field with tripod and level, scraper and cement mixer.

Fig. 3. Meade County State Lake. Photograph, 1945, courtesy Dr. Claude W. Hibbard.

Storage of water in Kansas has long been advocated, and some progress made in a feeble way. Everyone, in a cursory way, knows the advantages of having a pond or stream on land. A more thorough study of advantages derived from a considerable water surface is sufficient to convince that it is time for the state to enter upon a program seeking to enlarge the state's area of water surface.

It is well to point out a few of these advantages. First of all, water areas tend to increase humidity, and a comparatively high humidity in an agricultural region is desired. Water in lakes and ponds also tends to raise the

water level in the ground, or perhaps it would be best to say the moist horizon. Crops near a body of water, as a rule, soil conditions being the same, are more productive. Water surfaces also tend to attract bird life. Bird life is helpful in insect and weed control. There is also considerable commercial value to a water surface. If the water is sufficiently deep and not allowed to become too stagnant it will produce food in the form of fish and edible water fowl, to say nothing of the vacational and recreational possibilities. An expanse of water tempers the cooking heat of summer winds. The foregoing citations intrigue the mind into investigating for other benefits. Space forbids a more lengthy recital.

There are a number of places in Kansas that could be turned into areas of water at a nominal cost, compared to what these places will cost in a few years. The state might do well to begin work on an extensive scale immediately to increase the water area. This work properly belongs in the hands of a commission with sufficient authority to purchase or secure through condemnation proceedings or gift such suitable lands as the state's finances will bear without additional burdens upon taxpayers.

During the last two years a considerable addition has been made to the water area of Kansas. This is a hopeful sign. The department encourages as best it can the building of lakes, the recreation of marshes and the inundation of lowlands. The largest single addition to the Kansas water area is the Santa Fe Railroad's huge reservoir at Cassoday, Butler county. This body of water is perhaps 200 acres in extent, ranging in depth from featheredge to probably 20 feet.

Fish and game associations are taking up projects of building lakes and swamps. The McPherson county organization built the necessary dam and dikes to inundate a considerable area for fishes and fowl. Other county organizations have done preliminary work. The city of Herington has built a reservoir containing at its maximum area about 180 acres, with a depth near 30 feet. Then there are other projects either under way or contemplated.

However, it is apparent that the bulk of the job of enlarging the Kansas water area must fall upon the state. When it is considered that Arizona, supposed to be the driest state of the Union, has almost half the water area of Kansas, would it not be unwise to oppose an enlargement program? Sportsmen of Kansas are willing to pay practically all, if not all, the cost. Certainly, if hunters and fishermen want it and are willing to put up the money, opportunity for objection does not occur.

Forestry, Fish and Game Commission. Probably because he had won the enthusiastic support of the fish and game associations, Warden Doze had little difficulty in securing legislative action necessary to initiate his state lake plans. The legislature of 1925 created a forestry, fish and game commission, membership of which included the governor, the state warden, and three other members appointed by the governor and senate. The commission was authorized to acquire title to lands and waters, to build reservoirs, lakes and dams, to supervise the planting of trees, and to provide for fish hatcheries and game farms on state parks. The use of eminent domain was authorized where necessary to acquire lands.[11] A sum of $40,000 was transferred from the fish and game department to the commission.[12] With that amount it was obvious that no major program of purchase and development could be undertaken. Of necessity the first biennium was devoted principally to the inspection of sites and the preparation of plans.

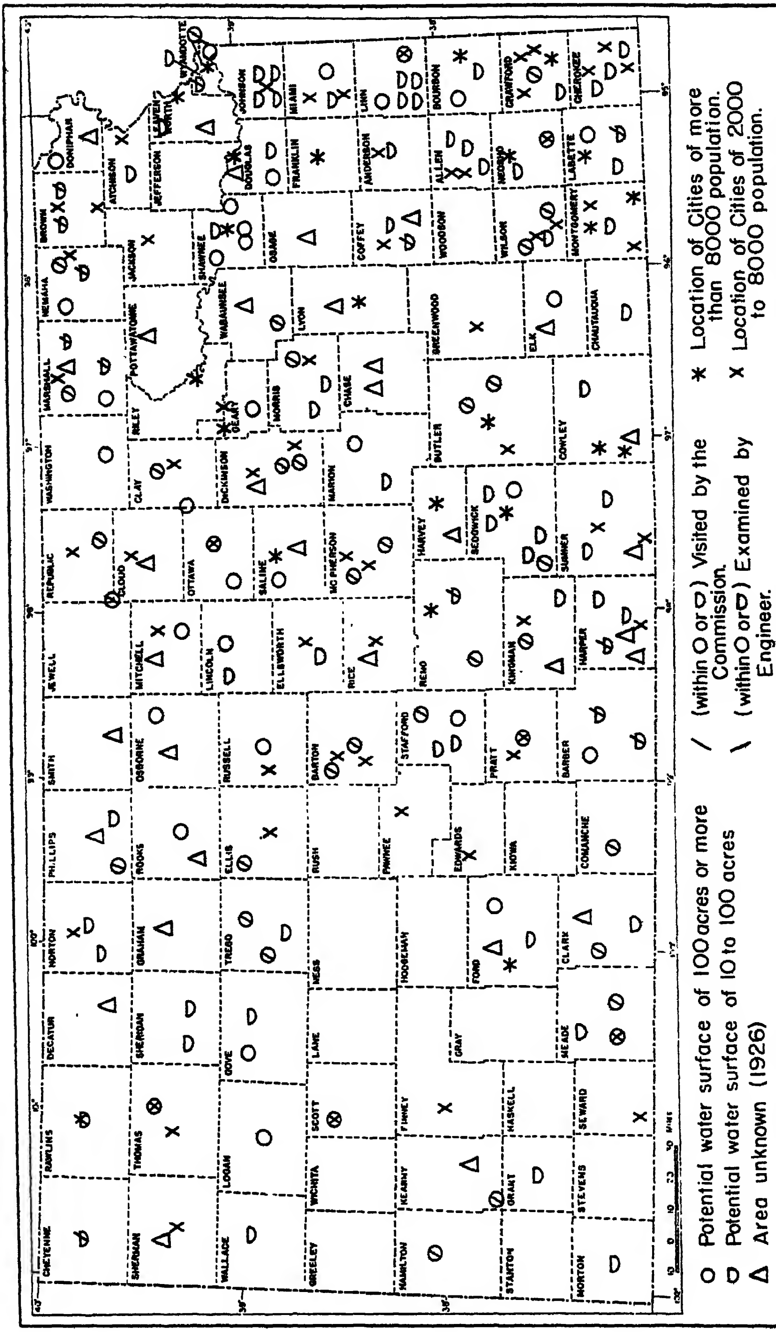


Fig. 4, Potential Kansas Lake Sites Proposed to the Commission, 1925-26. From the First Report of the Commission, 1926.

The commission met in Topeka in October, 1925, and started on a motor tour of prospective lake sites. On a series of such tours during the first biennium, they visited more than fifty proposed sites and met with local delegations in several cities. Interest in the program was so widespread that within a short time one or more proposals had been submitted by nearly every county in the state. A set of standards had to be adopted as a guide to determination of sites that might be developed. These standards included sociological factors such as population and local sentiment as well as land contour and character of the soil.[13] In 1926, also, an engineer was employed to inspect a few of the more promising locations.

The progress of the lake program was hastened by the fact that several communities began to take action without awaiting the next legislative session. Sportsmen of Crawford and Neosho Counties purchased the lands in the proposed lake areas and donated them to the commission. Citizens of Atwood, when informed that there was no prospect of a state lake in the next biennium, issued bonds and undertook the construction work with local funds. In one instance a deed offered jointly by three counties was refused after the engineer reported adversely on the prospects of successful establishment of a lake.

In 1927 the legislature placed the fish and game department under the supervision of the forestry, fish and game commission and authorized the use of hunting and fishing license fees for the lake and park program. Shortly thereafter an active construction program was under way, with the result that by the end of 1928 parks had been established and lakes were nearing completion in Meade and Scott Counties in the west, Ottawa County in the central part of the state, and in Crawford and Neosho Counties in the southeast. Another park was established in Leavenworth County in the northeast in the biennium that followed.[14]

Costs made it impossible, however, to finance the state lake program from hunting and fishing license fees at the rate that the public demanded. Warden Clapp in 1930 called attention to the fact that on the basis of the average of $110,000 for the first six lakes it would be impossible to establish more than about one lake each biennium unless other funds were made available. Such a rate fell far short of public demands and, as a result, the pressure for other appropriations became a source of embarrassment to legislators and political party leaders. The legislature was not willing to make appropriations for lakes and parks from the general state

Fig. 5. Leavenworth County State Lake, Tonganoxie. One of the few wooded lakes of Kansas. Photograph, courtesy Dr. L. C. Cox, Tonganoxie.

funds. The most that it would do was to authorize counties to establish and support lakes and parks.[15] This piece of legislation did little to meet the demands, however, as is suggested by the fact that in 1930 an independent candidate who adopted as part of his platform the slogan, "a lake in every county", came within a hair's breadth of being elected governor on a write-in vote.

Nevertheless the lake and park program almost came to a complete standstill after 1930. The commission reported in 1932 that it was unable, due to economic conditions, to continue the construction work.[16] The counties likewise were unable to exercise the

Fig. 6. Leavenworth County State Lake. The boat and bathing area. Photograph, courtesy Dr. L. C. Cox.

powers granted by the legislation of 1929. For a time it seemed that hopes for more lakes had faded into the far distant future. Then suddenly a new opportunity appeared in the form of the federal employment relief program.

C. C. C. No account of the development of state lakes and parks would be complete without the consideration of the work of the Civilian Conservation Corps. This work-relief agency, brought into being by Congressional Act of March, 1933, provided a large labor supply and made possible the construction of lakes at a cost to the state of only about one-tenth that of the first five lakes. Conversely the state park and lake program, for which plans already had been prepared and lands already made available through offers of sale or donation, provided an almost ideal set of projects for C.C.C. encampments. No less than eight state lakes were built by the C.C.C., and others already in existence were completed or improved. Yet the state lakes represented only a small portion of the work along that line performed in Kansas by the C.C.C. Local governments likewise took advantage of federal offers, and of the powers granted under the state legislation of 1929. Literally dozens of county and city lakes came into being during the years between 1933 and 1940.

Other federal relief funds served also to hasten the progress of the park and lake developments. As is shown by Table I on page 135, relief labor provided through the services of the Kansas Emergency Relief Committee, and of the Federal Works Progress Administration made possible the construction of several state and local lakes. So rapid was the development of lakes and parks under these relief programs that by 1940 the goal proposed by J. B. Doze and popularized as a campaign slogan by Brinkley was not far from a reality. There was not a lake in every county, but there were in the neighborhood of 100 artificial lakes in the state, a majority of them built in the five year period between 1935 and 1940.

Wartime Suspension. Necessarily the construction programs came to a standstill after Pearl Harbor. Several county and city projects long since approved by the water resources division of the state board of agriculture remain still in the planning stage, and doubtless many of them will remain so, at least so long as demands for labor exceed the supply. Experiences of the past decades suggest that great activity in the development of artificial lakes and parks is apt to be associated with economic depression and unemployment rather than with prosperity.

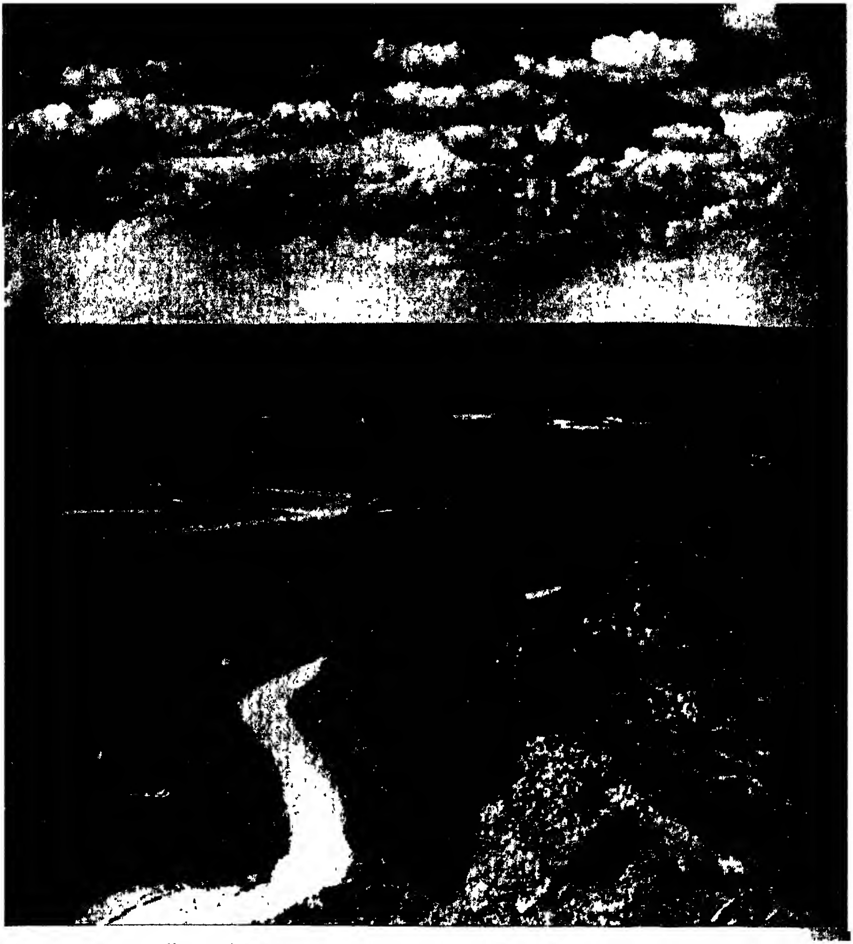


Fig. 7. Scott County State Lake and Park, 1938. Photograph, courtesy Kansas State Forestry, Fish and Game Commission.

New Federal Projects. There is a promise, however, of the addition of at least two major water areas in Kansas in the near future. One of these is the Cheyenne Bottoms, which already have gone through a cycle of flooding and drainage projects. After Congress had passed an act in 1938 providing grants in aid to states for wildlife restoration, the state commission, in cooperation with the United States Wild Life Service, undertook the development of the Bottoms as a migratory bird sanctuary. Over 12,000 acres of land have been purchased thus far, and the purchase of about 6,000 acres more is contemplated. The plans provide for the construction of an 11,000 acre lake.[17]

The other major project is associated with the Missouri Valley development programs. In fact, a half dozen water reservoirs al-

ready are authorized or under construction in the Kansas and Verdigris River basins, and numerous other proposed projects are under investigation.[18] These reservoirs are designed primarily for flood control purposes, but the Flood Control Act of 1944 provides also for the development of recreational facilities at the flood control reservoirs.[19]

Currently the most promising project, from the point of view of developing recreational areas, is the Kanopolis Reservoir in Ellsworth County. The Kanopolis Dam across the Smoky Hill River was under construction when the United States entered the second World War. Work is now being resumed after a four year suspension. Already plans have been prepared for the development of recreational facilities. Ten areas have been selected on the proposed reservoir for development as group camps, individual lease sites, boating headquarters and fishing areas.[20] In general the federal plans for water reservoirs appear to anticipate the development of more complete and more varied recreational facilities than any thus far established at state lakes and parks.

In Summary. Thus the conservation of water resources in Kansas continues to expand. In the beginning the prevailing type of reservoir was the farm pond, and the chief purpose was the conservation of water for live stock. All projects, recreational and other, were privately financed, though the state provided encouragement by way of plans and information, by assistance in stocking ponds with fish, and later by limited tax abatements. When the state entered into the construction program, the primary purpose was to increase the fish and wild life resources and to develop the recreational facilities. Later this program was accelerated with federal support, because the kind of work required was well suited to a new major objective—the provision of work relief for the unemployed. Under this program counties, as well as the state, joined in the lake-park construction activities. At about the same time and also with federal aid, many cities, faced with possible water shortages, undertook lake building projects in order to provide water reservoirs, and, incidentally, to increase their recreational facilities. The latest phase of this developmental process, a phase that is only now beginning to enter the picture, is the flood control program in Missouri River Basin. This program of development promises the establishment of large water reservoirs at several points along the rivers of the state, and these reservoirs, like city reservoirs, will be developed for recreational uses as well as for flood control and water

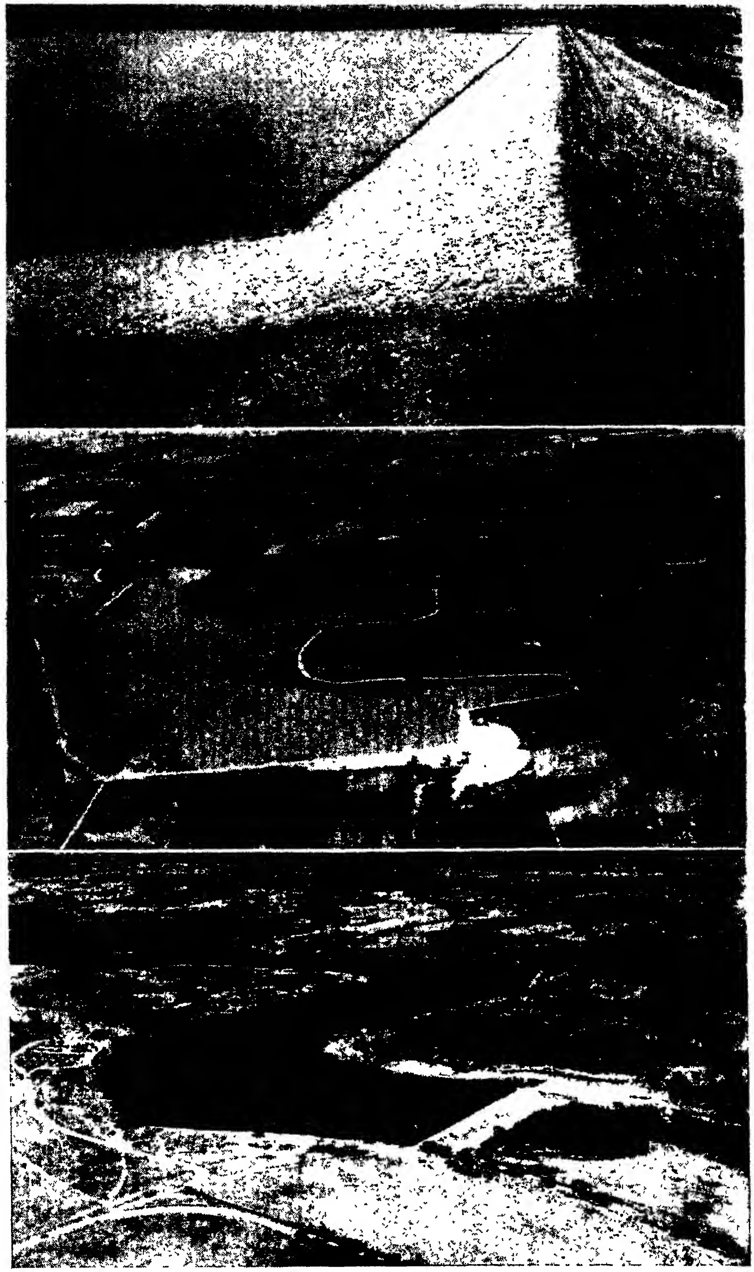


Fig. 8. Upper—Dam and outlet valve, Council Grove (Morris County) City Lake. Photograph, courtesy Mr. S. A. Sulentic, Topeka.

Middle—Atchison County Lake. Photograph, courtesy Division of Water Resources, Kansas State Board of Agriculture.

Lower—Howard (Elk County) City Lake. Photograph, courtesy Division of Water Resources, Kansas State Board of Agriculture.

conservation purposes. The projects are under direction of the War Department of the United States, whereas sites are investigated and plans prepared in Kansas by the water resources division of the state board of agriculture.

Problems. A large majority of the lake construction projects in Kansas thus far have been successful. Perhaps the most serious difficulty is the tendency of the lakes in many localities to fill with silt. One city clerk reported, for example, that "it took just three years to completely fill our lake with sediment." Another official reported regarding the local city lake, that "it was a nice lake but is getting badly filled." Perhaps a half dozen local lakes in the state have been abandoned for similar reasons.

Fig. 9. Rooks County State Lake, Stockton. A Prairie Lake. Photograph, E. O. Stene.

Even where sedimentation has not been so extensive as to cause the disappearance of a lake there have been instances where the silt deposits have tended to destroy lake bottom vegetation, and consequently fish as well. Sandy swimming beaches have been turned to mud bottoms because of the deposits. This is true even of one of the very few natural lakes, where a one-time sand bottom is now covered with several feet of silt.

Most of the artificial lakes in the state have fallen short of fulfilling the high hopes and the dreams of the fisherman. Reports of "good fishing" in city and county lakes are disappointingly few. On the whole the state lakes have a better record. Because they are under the direct supervision of the forestry, fish and game commission, these lakes have been watched more closely than most of the local lakes. Moreover, the dams are so constructed that the lakes may be drained, partially or completely, in order to permit the growth of new vegetation or the removal of excess and undesirable

fish population if necessary. Even so, the department is constantly faced with the problem of maintaining an adequate supply of full grown game fish in all state lakes.

Maintenance and management of lakes and parks also present problems. Well-kept grounds, well-managed concessions, and the maintenance of attractive standards of conduct among visitors, all contribute to the attractiveness of public parks and lakes. In fact, the most popular lakes are not necessarily the best fishing grounds. But adequate maintenance requires money, it requires the careful selection of personnel, and it requires the establishment of high standards for concessionaires.

At present there is considerable variation in the appearance of state parks. A few of them are attractively maintained. Others have not yet been developed, and still others appear to have deteriorated somewhat. A few have been left intentionally in a relatively undeveloped condition. Present conditions, however, cannot be regarded as typical, because wartime labor shortages have made it impossible to retain adequate personnel during the past few years. The problem for the future is one of securing income sufficient to maintain existing parks and lakes and at the same time to accumulate funds for future development. The question still remains whether the maintenance of state parks and lakes should be financed entirely from hunting and fishing licenses.

The control of commercial enterprises is an important aspect of maintenances of lakes and parks. The forestry, fish and game commission has followed the policy of granting concessions to private operators, and in many instances these operators have constructed their own buildings and other permanent equipment. Although this arrangement is economical, it has caused some embarrassment in instances where the concessionaires have proved undesirable. Thus far, however, the methods of control may be regarded as largely experimental. A few cities operate boating services and other similar services on a direct employment basis, with apparent success. In most instances where commercial services are provided at county and city lakes, however, the system of private concessions is followed. The recreational plans for the Kanopolis Reservoir anticipate the same kind of arrangement. However, the district office of the corps of engineers has announced that concessions will be granted "only after a review of the completeness and quality of the facilities and services to be offered, and other considerations, rather than purely on a maximum return to the Government."

Fig. 10. Sedan (Chautauqua County) City Lake. Photograph, courtesy Division of Water Resources, Kansas State Board of Agriculture.

Data On Principal Kansas Public Lakes

The four tables on the following pages contain data regarding the history, area, and other conditions of the twenty-one state parks and lakes, of seventeen county lakes, and of sixteen larger city lakes in Kansas. Information regarding state lakes has been taken from reports of the forestry, fish and game commission and in part from records of the water resources division of the state board of agriculture. For county or city lakes the data also have been obtained from the water resources division (whose approval is a legal prerequisite to the construction of dams), and from replies to questionnaires sent to cities and counties. Not all questionnaires were returned, and so the data for some of the local lakes are incomplete.

Lakes in Anderson and Wabaunsee Counties, for a few years listed as state lakes, are no longer included in the reports of the forestry, fish and game commission. They are managed as city lakes, by the cities of Garnett and Eskridge, respectively, and are listed below in Table III.

Table IV gives some indication of the large public interest in Kansas lakes.

Table I—State Lakes

	LOCATION County	Nearest City	Area of Park (Acres)	Surface Area of Lake (A)	Capacity (Acre Ft.)	Max. Depth of Lake	Land Acquired by	Dam Built By	Com-pleted	Opened to Fishing	Park Supt. (1944)
1.	Butler	Augusta	568	232	1,610	70 ft.	Lease	Santa Fe R.R.	(Before 1925)	1934-a	Yes
2.	Clark	Ashland	1,289	337	7,662	60 ft.	Donation	C.C.C.		1941	No
3.	Crawford No. 1	Pittsburg	418	60		54 ft.	Donation	(Strip Mine Pits) (b)		1927	No
4.	Crawford No. 2	Farlington	465	150	3,474		Donation	C.C.C.	1938	1939	No
5.	Decatur No. 1	Oberlin	97	47	130	14 ft.	Purchase	Highway Dept.	1932	1939(c)	
6.	Decatur No. 2	Oberlin	481	161	807	10 ft.	Donat on	C.C.C.	1938	1940	Yes
7.	Finney	Garden City	853	324	4,359	36 ft.	Don. & Purch.	C.C.C.	1934	1937	No
8.	Kingman	Kingman	1,562	80		6 ft.	Purchase	Comm. and C.C.C.	1934	1934	No
9.	Leavenworth	Tonganoxie	506	175	3,932	56 ft.	Purchase	Commission	1931	1933	Yes
10.	Lyon	Reading	582	135	1,889	43 ft.	Purchase	C.C.C.	1935	1939	No
11.	Meade	Meade	1,240	100	860	37 ft.	Purchase	Commission	1928	1930(d)	Yes(g)
12.	Miami	Fontana	277	90			Purchase		(Before Purchase)		No
13.	Nemaha	Seneca	705	356	3,660	32 ft.	Donation	C.C.C.	1938	1939	Yes
14.	Neosho	Parsons	216	92	756	31 ft.	Donation	Commission	1927	1929	Yes
15.	Ottawa	Minneapolis	711	138	1,070	25 ft.	Condemnation	Commission	1929	1931(e)	Yes
16.	Pottawatomie	Blaine	100	30	300	35 ft.	Purchase	Highway Dept.	1933	1940	No
17.	Republic	Jamestown	1,064	765	1,000	6 ft.	Purchase	Commission	1932	1934(e)	No
18.	Rooks	Stockton	333	67	516	25 ft.	Donation	K.E.R.C.	1934	1940	No
19.	Scott	Scott City	1,280	115	930	22 ft.	Purchase	Commission	1930(f)	1932(e)	Yes
20.	Sheridan	Quinter	436	124	912	21 ft.	Donation	C.C.C.	1937	1940	No
21.	Woodson	Toronto	446	126	1,797	50 ft.	Donation	C.C.C.	1937	1938	Yes

Table II—County Lakes*

	County	City	Plans Approved by Water Resources Div.	Dam Completed	Surface Area of Lake(A)	Capacity (Acre Feet)	Max. Height of Dam	Fulltime Care-taker	Local Fees for Fishing
1.	Atchison	Horton	1934	1935	91	819	35 ft.	Yes	Yes
2.	Bourbon	Ft. Scott	1934	1935	106	485	39 ft.	Yes	No
3.	Clay	Clay Center	1934	1935	18	102	20 ft.	No	No
4.	Decatur(h)	Jennings	1934	1935	(Washed Out)				
5.	Douglas	Lone Star		1939	195	3,957	63 ft.	Yes	Yes
6.	Ellsworth	Hollywood	1935	1937	23	146	23 ft.	No	No
7.	Ford(h)		1936	1937	65	487	24 ft.	(No report)	
8.	Graham	Morland	1934	1935	85	709	31 ft.	No	No
9.	Jewell(h)			1928	15	75	13 ft.	(No report)	
10.	Logan	Russell Springs	1936	1939	(Reported almost dry)		28 ft.	No	No
11.	Marion	Marion	1936	1939	152	2,472	42 ft.	Yes	Yes
12.	Norton(h)		1936	1938	69	407	38 ft.	(No report)	
13.	Pratt	Pratt	1936	1938	96	447	12.5 ft.	Yes	Yes
14.	Riley(h)		1934	1935	(Does not hold water)				
15.	Shawnee	Topeka	1935	1937	393	7,500	58 ft.	Yes	Yes
16.	Sedgwick	Garden Plains	1939	1940	238	2,996	43 ft.	Yes	Yes
17.	Wyandotte	Kansas City	1936	1940	305	6,900	90 ft.	Yes	Not open

*Harvey and Sumner Counties have "overflow dams" on the Little Arkansas and the Ninnescah rivers, respectively.

TABLE III—Larger City Lakes (Over 400 Acre Ft. Capacity)

City	Distance from City	Plans Approved by Water Resources Div.	Dam Completed	Surface Area (Acres)	Capacity (Acre ft.)	Max. Height of of Dam	Local Fees for Fishing
Atwood (twp.)	1 block	1933	1935	160		8 ft.	No
Anthony	2 mi.	1934	1935	135	950	32 ft.	Yes
Augusta	½ mi.	-------	1931	180	1,820	41 ft.	Yes
Council Grove(h)		1940	1942	387	8,416	65 ft.	
El Dorado	3½ mi.	-------	1927	315	1,550		Yes
Emporia	20 mi.	1935	1936	405	6,603	60 ft.	Yes
Eskridge	4 mi.	-------	1936	202	3,458	64 ft.	Yes
Eureka(h)		1935	1939	259	3,690	57 ft.	
Gardner	2½ mi.	-------	1937	131	2,351	58 ft.	No
Garnett	0	-------	1937	48	839	56 ft.	
Herington		-------	1922	410	3,505	31 ft.	
Horton	½ mi.	-------	1924	175	1,576		No
Howard	1¼ mi.	1934	1935	60	777	42 ft.	Yes
Olathe	2½ mi.	1931	1931	56	490	32 ft.	Yes
Paola	4 mi.	1934	1935	40	470	29 ft.	Yes
Plainville (twp.) (h)		1935	1938	158	1,037	27 ft.	
Sabetha(h)		1935	1936	112	1,255	77 ft.	
Sedan	3½ mi.	1934	1935	55	660	37 ft.	Yes
Wellington	10 mi.	1934	1935	349	3,066	32 ft.	Yes

TABLE IV—Park Use Data for Fiscal Year 1940 as Estimated by Caretakers and Other Agents (k)

County State Park	Fishers	Picnickers	Total Visitors
Butler	16,946	24,795	103,710
Crawford No. 1	4,875	4,072	32,805
Crawford No. 2	9,729	632	34,376
Decatur No. 2	2,448	7,851	13,324
Leavenworth	10,948	16,624	67,103
Meade	3,327	5,074	12,288
Neosho	10,751	8,602	14,426
Ottawa	4,501	12,184	81,865
Scott	3,068	6,752	13,210
Woodson	19,008	3,930	29,009
Totals	85,601	90,516	402,116

NOTES ON TABLES

a. This date is given in the *Seventh Biennial Report,* 1938. The lake may have been open to fishing when the commission leased it from the Santa Fe Railroad and for a short time thereafter.

b. Crawford County State Park No. 1 contains several small ponds in abandoned surface coal mine pits. These bodies of water existed when the land was donated to the state.

c. Duck hunting is permitted in these lakes.

d. Closed in 1941 for drainage and improvement, including the removal of rough fish; reopened for fishing in 1944.

e. Not open for fishing in 1946; partially drained for cleaning and to permit regrowth of vegetation.

f. Dam partially washed out by flood in 1933; rebuilt by the C.C.C.

g. Superintendent of Meade Park Game Farm.

h. No direct reports received from these counties and cities.

i. City plans to require a local fishing fee in the near future.

k. *Eighth Biennial Report,* p. 19.

LITERATURE CITED

(1) *Areas of the United States, 1940,* Sixteenth United States Census, 1942, p. 6.

(2) CF. *Third Biennial Report of the State Fish Commissioner,* 1882, pp. 16-39; and *Annual Report* 1893, pp. 3-7.

(3) *Topeka State Journal,* Jan. 24, 1899.
(4) *Wichita Eagle,* May 9, 1900.
(5) *Topeka State Journal,* May 1, 1900; *Laws of Kansas,* 1899, ch. 151.
(6) *Kansas City Journal,* Aug. 2, 1914.
(7) *Kansas Fish and Game,* Sixth Biennial Report of the Fish and Game Department, 1926, p. 12.
(8) STENE, "Wildlife Conservation in Kansas," these *Transactions,* v. 47, p. 289 ff (Mar., 1945).
(9) Ibid., pp. 315, 321; *Kansas Fish and Game,* Mar. 1942, p. 2.
(10) *Fifth Biennial Report of the State Fish and Game Department,* 1924, pp. 6-7.
(11) *Laws of 1925,* ch. 257.
(12) *Laws of 1925,* ch. 13.
(13) *First Report of the Forestry Fish and Game Commission,* 1926, pp. 11-12.
(14) *Second Biennial Report,* 1928, p. 7.
(15) *Laws of 1929,* ch. 158.
(16) *Fourth Biennial Report,* 1932, p. 25.
(17) *Ninth Biennial Report,* 1942, p. 32; *Kansas City Star,* Feb. 4, 1945, p. 1B.
(18) Report of the Kansas State Board of Agriculture, *A State Plan of Water Resources Development,* v. 63, No. 294. (Map of projects in envelope attached to inside back cover).
(19) *58 U. S. Stat.* 889-890 (78th Congress, 2nd Session, ch. 665, sec. 4).
(20) *Kanopolis Reservoir, Proposed Development of Recreational Facilities,* War Department Corps of Engineers, Kansas City District, April, 1946.

The Editor's Page

Transactions
of the
Kansas Academy of Science

Published Quarterly
by the
KANSAS ACADEMY OF SCIENCE
(Founded 1868)

OFFICERS

Claude W. Hibbard, Lawrence, President.
Donald J. Ameel, Manhattan, Secretary.
S. V. Dalton, Hays, Treasurer.

VOL. 49, NO. 2 SEPTEMBER, 1946

ROBERT TAFT, *Editor*

Here it is September fourth and no editorial ready for the September issue and the editor's conscience troubles him and has been troubling him for some time for he dislikes putting off his duties until the last moment. But amid his present surroundings the editor, or no other mortal, should be troubled. To achieve complete peace with his conscience and his surroundings, the editor then starts committing his thoughts to paper, writing them for the lack of any other medium upon a kind of paper which, at the present moment, is a very scarce commodity. This out-door editorial is being written at Blue Lakes Camp Ground; elevation 10,000 feet, latitude 37.5° north, longitude 105° west of Greenwich. Which is to say that it is written at a picnic bench high in the mountains of southern Colorado in the San Isabel National Forest, a few miles west of the famed Spanish Peaks; or to put it still a little differently, in the mountains of what once was southwestern Kansas Territory. This spot of peace and beauty is reached by no boulevard but by a rough but passable mountain road which leaves behind it a green and lovely valley, the Cuchara valley, one of the most attractive in the whole state of Colorado*; and Colorado (much of which was once Kansas Territory to harp again on our past mistakes) possesses far more than its share of beauty.

Within a stone's throw, however, of the editor's present location is Blue Lake formed by a beaver dam across a small rushing stream. Over the next ridge is Bear Lake, another similar body of water. The mountain slopes as they rise above the camp grounds on all sides are clad at first with innumerable hosts of the slim spires of Douglas fir, interspersed by occasional patches of the gray-green aspen with the leaves of never-ceasing motion. Farther up the mountain sides, the heavy forest growth gives way to stunted cedar as timber line is approached and

*The Cuchara (or Cucharas) valley is reached by leaving U. S. Highway 160 at La Veta and taking Colorado Highway 111.

finally the slopes become barren and rocky. Trinchera Peak, the dominating land mark in the scene rises with thinly snow-covered head, 13,546 feet above the level of the lowly sea. The editor doesn't have to look that figure up because he climbed the peak five or six years ago and was nearly crippled for two or three days after that event. During his convalescence he studied and read and re-read the maps supplied by the local ranger so the elevation of Trinchera has stuck firmly in his mind since that memorable excursion.

But now, looking up three thousand feet and more to the summit of Trinchera and beyond, giant sweeps and swirls of cirrus clouds can be seen above the peak in the deep, the very deep blue Colorado sky. Probably the view as the editor now sees it has not greatly changed in its general features for the past thousand summers. A timelessness and tranquility pervade the scene that brings a welcome relief from a tired, troubled and turbulent world. Only when one looks down do there appear signs of the modern day. For around the several camp-fire sites are beer cans, broken whisky bottles and empty food containers, carelessly left by slovenly housekeepers in one of their most valuable possessions. Even careless housekeeping, however, cannot mar for long the natural beauty of the scene. By next summer the blue gentian, the alpine paint brush, the mountain aster and other colorful cover will hide these evidences of civilization. Careless housekeeping, however, should not be excused for this camp-ground is mine; it is yours; it is ours. Pride of possession should be sufficient incentive to keep this and all similar virgin areas in their state of native cleanliness.

Prideful recollection, too, should be made of those individuals who through their foresight, time and talents have been responsible for the inception, perpetuation and maintenance of our national forests and national parks. These lands are a heritage to be maintained with individual and national pride and dignity for our own and future generations and to be guarded with utmost aggression against any interfering forces tending to destroy their boundaries and their beauty or to commercialize, beyond the bounds of good conservation practices, their resources.

Their greatest value lies in the peace, the enjoyment, the satisfaction, and the lasting and restorative memories they have brought — and will bring — to countless citizens whose tastes are simple, fundamental and appreciative of our great and varied American outdoors.

* * *

Dr. E. O. Stene of the department of political science, University of Kansas, is the first contributor to the *Transactions* to achieve the honor of publishing two feature articles in this journal. In March, 1945, his review of the development of Kansas wild-life policies brought wide recognition to Dr. Stene and the *Transactions*. Request for copies of the article have come from many sources, both at

ing such an able and productive student of her many departments and activities.

A brief biographical sketch of Dr. Stene, together with his portrait, will be found in the March, 1945, issue of these *Transactions.*

* * *

The news column which follows in this issue records numerous additions to faculties of Kansas colleges; such additions appear to be of general occurrence throughout the country. A friend at the University of Ohio recently told the editor, for example, that shortages of housing and competent teachers were their great problems and on a trip to Colorado late this summer, teachers in our sister state reported similar difficulties. One of the more disturbing features, however, of the times, is the large number of resignations, including many from our younger and abler men, recorded in this issue. (Note that those resignations include only those in the sciences). Nearly all of these resignations come as a result of increased pay and increased professional opportunities in larger schools outside the state. Kansas colleges and universities should not become merely training grounds for competent teachers and researchers in securing experience before going on to other fields of activity. The matter should have the immediate attention, not only of our college administrators, but of teachers themselves and the Kansas public generally.

home and abroad, including one from Oxford University in England. The article was also reprinted by the Bureau of Governmental Research, University of Kansas, for distribution to the sportsmen of Kansas through the agency of the 105 county clerks of the state. We predict for his article in the present issue on Kansas lakes and recreational areas an equally wide recognition. In addition to the two articles published by the *Transactions,* Dr. Stene has recently completed *Railroad Commission to Corporation Commission,* a study of state public utility regulations, published by the Bureau of Governmental Research, and he has also nearly completed a study of the development of the Kansas State Board of Agriculture. Kansas is to be congratulated in possess-

St. Paul's Advice to Teachers

If the trumpet give an uncertain sound, who shall prepare himself for war? So also ye, unless ye utter by the tongue speech easy to be understood, how shall it be known what is spoken? For ye will be speaking into empty air.

Scientific News and Notes of Academy Interest

Items for this column are solicited from all Academy members. For inclusion in any given issue they should be in the editor's hands at least three weeks before our publication dates, namely the fifteenth of March, June, September and December.

Dr. Claude W. Hibbard, president of the Academy and since 1935 a member of the staff of the University of Kansas has resigned his position at the University to accept a position as associate curator of vertebrate paleontology in the museum of paleontology at the University of Michigan. The resignation of Dr. Hibbard is a distinct loss to science in Kansas as he was one of the state's most productive workers and for many years an active and loyal member of the Academy.

Dr. Stuart M. Pady, newly elected secretary of the Academy and associate professor of botany and plant pathology, Kansas State College, Manhattan, has resigned his position to accept an associate professorship in botany at McGill University, Montreal, Canada.

Newspapers of the Kansas area have been utilizing material from the *Transactions* to a greater extent in the past few years. For example, the Kansas City *Times*, condensed Dr. Wedel's account of "The Kansa Indians" in our June issue and used it as a feature article on their editorial page for August 21, 1946.

Dr. W. M. Jardine, president of the University of Wichita, who became critically ill with meningo-encephalitis while vacationing in Colorado in August, has been returned to Wichita for convalescence. At this writing he is a patient in Wesley Hospital but is expected to be returned to his home on the campus within a few days. His progress toward recovery is satisfactory, according to attending physicians; however, they have not yet declared him out of danger.

Dr. Harry H. Sisler, associate professor of chemistry at the University of Kansas, has resigned his position to accept an assistant professorship at Ohio State University, Columbus. Dr. Sisler, for five years a member of the University of Kansas staff, began his present duties with the beginning of the fall semester.

Mammals of Nevada by Dr. E. Raymond Hall, director of the University of Kansas Museum of Natural History, published during the past summer, is an exhaustive treatise not only on the lesser mammals of Nevada, but on larger mammals, bears, foxes, coyotes, wolves, beavers, deer and antelope, as well. The treatise is the result of many years research and field work on the part of Dr. Hall during his stay at the University of California.

The book is published by the University of California Press, Berkeley (710 pages, 485 illustrations, $7.50).

Dr. Harvey A. Zinszer, professor of physics at Fort Hays Kansas State College, taught this past summer at his alma mater, Lehigh University, Bethlehem, Pa.

Mr. Blaine E. Sites, for the past several years science instructor in the Salina High School, has been named temporary physics instructor at Kansas State College, Manhattan.

During the past summer, three well-known milling authorities from abroad visited the department of milling industry, (one of two such departments in the world) of Kansas State College, Manhattan. Dr. Sven Hagberg, on an official mission from the Swedish government, studied the manner of conducting milling courses at Manhattan with a view to the establishment of similar courses in Sweden. A similar mission was conducted by Dr. P. Holton and Mr. R. H. Carter, cereal chemists from England.

Dr. William C. Young will become associate professor of anatomy at the University of Kansas. Dr. Young is a graduate of Amherst College and received his doctorate at the University of Chicago. He has had teaching or research experience at Chicago, Brown, Yale and Freiburg (Germany) Universities.

Dr. Anthony Smith, formerly instructor at the Universities of Minnesota and Illinois, becomes assistant professor of psychology at the University of Kansas. Dr. Smith received his doctorate from the University of California at Los Angeles.

Dr. Stuart M. Pady of Kansas State College and Dr. W. H. Schoewe of the University of Kansas served from August 27th to 30th as botany and geology instructors respectively at the 4-H Club Conservation Camp in the Flint Hills country south of Junction City. Lectures and field trips were made at the camp which included boys and girls assembled from over the entire state.

Dr. Donald J. Ameel, after serving the past year as acting head of the department of zoology, Kansas State College, Manhattan, has been made permanent head of the department.

Mr. J. M. Porterfield, who received his master's degree from the University of Missouri, will become instructor in general physics at the University of Kansas. Mr. Porterfield has had teaching experience at Northwest Missouri State Teachers College.

The establishment of a large center for training in clinical psychology was announced during the past June. The center is a cooperative effort on the part of the Menninger Foundation of Clinical Psychology, the Winter General Hospital of the Veterans Administration, Topeka, and the department of psychology of the University of Kansas, Lawrence. Dr. Raymond H. Wheeler, past president of the Acad-

emy, and chairman of the psychology department at the University, will be the executive director of the center, which has at present a combined staff of 31 members. Training for graduate students in clinical psychology leading toward master's and doctor's degrees will be offered. About one-third of the student's work will be done on the campus at the University and the other two-thirds as intern at the Winter General Hospital. A four year course for the doctorate is contemplated, students being paid by the Veterans Administration at the rate of $1200 for the first year of training, $1500 for the second year, and $1800 for the last two years. Under the terms drawn up jointly by the three cooperating institutions, students will be enrolled and examined at the University, and thesis direction will be carried out under joint direction of the University and the Menninger Foundation of Clinical Psychology of which Dr. David Rapaport is director.

The establishment of this center brings to Kansas one of the most important psychological research centers in the country.

The many friends of Professor William B. Wilson, past president of the Academy and a member of the Ottawa University biology staff since 1904, will regret to learn of his death on August 31, 1946, at the age of eighty years. His obituary will appear in a later issue of these *Transactions.*

Sister Mary Grace Waring of Marymount College, Salina, published in the July, 1946, issue of *The Kansas Nurse* (Wichita) a study presented at the spring meeting of the Academy at Emporia, "Chemistry Courses for Student Nurses Offered in Kansas Colleges". Sister Waring's study was based on questionnaires sent to 40 Kansas colleges and to 33 hospitals in the state, 85 per cent of whom responded. Twelve colleges of the state offer special chemistry courses for beginning student nurses, while 21 colleges offer no special courses. The usual course offered by colleges for student nurses in chemistry consists of two hours of lecture and a laboratory period of two hours for one semester. In addition to college students, which constitute about 60 per cent of the student nurses receiving training in chemistry, some 226 nurses received instruction in chemistry within hospitals. The method and content of the various chemistry courses offered is also discussed by Sister Waring.

Professor Earl D. Hay, since 1928 professor of mechanical and industrial engineering at the University of Kansas, has resigned to accept a similar position at Iowa State College, Ames.

Dr. Jacob Kleinberg has been appointed assistant professor of chemistry at the University of Kansas and will be in charge of courses in inorganic chemistry. Dr. Kleinberg received his doctorate from the University of Illinois in 1939 and has had teaching experience at James Millikan University, Decatur, Illinois, and the University of

Illinois College of Pharmacy, Chicago.

Dr. Robert Schatten, a native of Poland, becomes associate professor of mathematics at the University of Kansas. Dr. Schatten received his undergraduate training at the University of Lwow and then came to this country in 1936. He taught at Columbia and received his doctorate from the same institution. A commando in World War II, Dr. Schatten has had research and teaching experience at Princeton and Yale.

Dr. C. Hess Haagen, formerly of Franklin and Marshall College, becomes assistant professor of psychology at the University of Kansas. Dr. Haagen received his doctorate from the University of Iowa and received his undergraduate degree at Franklin and Marshall. He also has had teaching experience at Pennsylvania College for Women at Pittsburgh.

Dr. and Mrs. L. J. Gier of William Jewell College, Liberty, Missouri, made a trip from the Canadian Rockies to Mexico during the past summer. Dr. Gier, one of the Academy's most avid camera fans, took 720 feet of color movies and over a hundred color stills of subjects having biological and geological interest.

Mr. John A. White, a graduate of William Jewell College in 1942, has been added to the staff of his alma mater, to assist in courses in biology during the coming year.

Dr. Edward H. Taylor, professor of zoology at the University of Kansas, has been added to the staff of the Museum of Natural History as curator of herpetology.

Professor Roy Rankin of Fort Hays Kansas State College, Hays, has recently published a brief monograph *Municipal Water Softening in Kansas*. Copies of the bulletin may be secured by addressing the librarian of the above institution. Professor Rankin's monograph is based on his personal study of 23 municipal water supply systems in the state. Seven of the 23 systems use wells as the source of their supply; three use both well and surface water and the remaining 13 systems depend upon surface water only.

In addition to the 23 systems personally studied by Professor Rankin, returns from 320 towns using well water as their source of supply were also obtained. Of the 320 towns, 250 towns have water of sufficient hardness to warrant them in installing and operating water softening equipment. Using both well and surface water systems, there are 270 towns of total population over 500,000 that would repay the installation of water softening equipment in Professor Rankin's judgment. A discussion of water softening equipment and methods is also included in Professor Rankin's report.

Dr. Eldon Fields, formerly an undergraduate student at the University of Kansas, returns to his alma mater as assistant professor of political science. After

receiving his doctorate from Leland Stanford University, Dr. Fields taught at Syracuse University and the University of Chicago. Dr. Fields will have charge of the social science survey courses at Kansas.

Dr. R. C. Mills, recently discharged from the U. S. Navy, will become assistant professor of biochemistry at the University of Kansas. Dr. Mills received his doctorate from the University of Wisconsin.

Dr. H. W. Marlow, assistant professor of chemistry, Kansas State College, Manhattan, resigned his position to accept a position in the department of chemistry at Texas Christian University, Dallas. Dr. Marlow has been a member of the Kansas State staff since 1932.

Dr. Elva Norris, since 1938 seed analyst for the State Experiment Station, Manhattan, has resigned her position to accept a similar one as state seed analyst for Georgia.

For the past several years, the *Transactions* has published in these pages brief accounts of the research centers in the Kansas area. The present account, the seventh in the series, deals with a research center of great immediate and practical value, the U. S. Weather Bureau at Topeka, Kansas. The following brief account of some of its methods and activities has been prepared by Mr. S. D. Flora, meteorologist for Kansas, and for 41 years associated with this Kansas weather station. Probably no name is better known in Kansas than is that of Mr. Flora, who, while he is not responsible

MR. S. D. FLORA

for Kansas weather has served long and faithfully in recording and predicting the vagaries of Kansas climate.

Mr. Flora writes: The network of weather reporting stations in Kansas grew from a very small number in the early 1880's until now it is one of the most comprehensive to be found in any state, with daily records kept at more than 250 places so well distributed that every county has at least one official record of rainfall and 94 have official temperature records. The U. S. Weather Bureau Office at Topeka, which has supervision of this network of observing stations, is staffed with nine persons and occupies 3,000 feet of well-filled floor space in the penthouse of the Topeka Post Office Building. In its files are the original records of all cooperative stations in Kansas covering the past 50 years, bound separately

in chronological order for ready reference.

Prior to 1887 only a few official weather records had been kept in Kansas. Some had been made at army posts under the supervision of the Surgeon General of the Army, and others under the supervision of the Smithsonian Institution. The oldest of these records was begun at Fort Leavenworth in 1836. The next oldest was begun at Fort Scott in 1843. The longest unbroken records in the state are those for Manhattan, begun in 1858, and Lawrence, begun in 1868.

In June, 1887, Mr. T. B. Jennings, then a sergeant in the Signal Corps, U.S.A., was assigned to Topeka with orders from the Chief Signal Officer to establish a network of observing stations over the state using the few already in operation as a nucleus. On July 1, 1891, the U. S. Weather Bureau was organized under the Department of Agriculture and took over all, except strictly Army, weather stations from the Signal Corps, which resulted in further interest and expansion in weather reporting. In 1940, the Weather Bureau was transferred intact to the Department of Commerce, where it could operate more closely in its airway work with the Civil Aeronautics Administration.

By October, 1898, the network of Kansas stations had increased to 66 and the publication of a monthly and annual bulletin giving daily values and summaries was begun. This bulletin, first called *The Climate and Crop Service of the Weather Bureau* and later called *Climatological Data,* has been issued regularly since then without material change in its style, except for a break from June, 1909, to January, 1914, when the data were published in *The Monthly Weather Review.*

In addition to these reports from cooperative stations, weather conditions in detail have been recorded for the past half century at first-order stations of the Weather Bureau at Topeka, Wichita, Dodge City, and Concordia, which are staffed with full-time employees. The Topeka office is unique among all weather bureau offices of the country in that since it was established 59 years ago but two men, Mr. T. B. Jennings and Mr. S. D. Flora, have been in charge.

Cooperative observers, called voluntary observers in the early days of the service—there are more than 6,000 of them in the United States—render a service so valuable that it is impossible to estimate its worth in dollars and cents, yet it costs the government practically nothing. It is doubtful whether the present complex agricultural and business economy of the country could exist without these detailed records. Men and women of every walk of life are found among the cooperative observers. Some of the most representative are farmers, housewives, bankers, college professors, and merchants. In nearly every case, these people are leaders in their respective communities.

These observers serve without pay, some for 30 to 40 years or more. The oldest observer in Kansas, in point of service, is

Mr. M. A. Webb of Toronto, who has kept an unbroken record for more than 46 years. Often the work of these observers is handed down from father to son or from father to daughter. At Norton, Kansas, Mr. Cale Sleffel is the third generation of his family to act as cooperative observer, continuing a record that was begun by his grandfather, Mr. H. A. Sleffel, 46 years ago. At McPherson, Mr. Ed Haberlein has for 26 years carried on the weather record begun by his father almost 60 years ago.

These records are carefully reviewed and checked monthly as they arrive at the Weather Bureau Office, Topeka, in order to eliminate minor errors. Records such as these, however, kept by public-spirited and disinterested persons, are considered to represent correctly weather conditions as they actually occur from day to day and are accepted without question by investigators, and are considered prima facie evidence in courts of law.

As to their value, Dr. Isaiah Bowman, President of the American Association for the Advancement of Science, 1943, made the following statement: "Facts more valuable than all the gold of the Klondike lie buried in the Weather Bureau's climatological records."

For the greater part of the past year the Topeka office of the Weather Bureau has been compiling data from these accumulated records for a new publication *The Climate of Kansas* which will be a mine of information concerning the weather and climate of the state. The cost of printing this 350-page bulletin will be sponsored by the Kansas State Board of Agriculture and it is expected to be ready for distribution within the coming 12 months.

Dr. R. K. Nabours, professor of zoology, Kansas State College, Manhattan, and past president of the Academy, has reached the retirement age and becomes professor emeritus. Dr. Nabours, however, will still continue his researches in genetics.

During the past summer, Dr. Claude W. Hibbard of the Museum of Natural History, University of Kansas, headed a field party of seven including Messrs. Russell Camp, Henry Hildebrand, Jaco Moojen, Richard Rinker, and Theodore Downs which made paleontological investigations in Logan and Weld Counties, Colorado. The area had been investigated some years ago by the late Handel Martin of the University of Kansas and the party was fortunate enough to secure the aid of Mr. Clyde Ward, a Colorado rancher, who knew Martin and was able to guide the group to many places where Martin had collected. Dr. Hibbard's party mapped and measured a number of sections of Oligocene deposits and were fortunate enough to discover many specimens. The prize of the summer's collection was the skull and lower jaws of a large pig-like animal discovered by Theodore Downs.

Wichita High School East reports increasing interest in beginning science courses. 465 sophomore students are enrolled

this fall in 15 biology classes. Mr. Clinton Kaufman, who has been teaching physics, now devotes most of his time to the teaching of biology and another biology instructor, Mrs. J. A. Griffith, has been added to the science staff.

Additions to the science staff at Baker University, Baldwin, include Mr. Robert L. Kulp, a graduate of the University of Wisconsin School of Engineering who will teach freshmen classes in mathematics and Mr. Jackson J. Austin, formerly teacher in the public school system of Topeka, who will assist in the biology department. The Baker University museum, formerly located in the basement of Parmenter Commons, has been moved to the top floor of the Commons building to provide additional housing for men students.

Mr. W. A. Mattice, formerly first assistant meteorologist of the U. S. Weather Bureau, Topeka, was transferred September first to the Cincinnati station to aid in the river and flood control program now under way on the Ohio River.

More than one hundred years ago, in *Democracy in America,* de Tocqueville predicted that the Mississippi Valley would become the home of the world's greatest civilization. Something of the extent to which the prediction has been fulfilled may be learned from reading Graham Hutton's *Midwest at Noon,* published in 1946 by the University of Chicago Press and priced at $3.50. The author, an able and candid Englishman, has spent several years in the Midwest and has traveled thousands of miles there and in other sections of the United States. Periods of residence in several European countries enrich his background.

Upon the whole, Hutton's statement supports de Tocqueville's prediction. At least it indicates that the prediction is in process of fulfillment. If, as Carl Sandburg has said, civilization consists in diversity of opinion, the Midwest is on the way to become highly civilized — on grounds of diversity, at any rate. The region, says Hutton, "lies between the latitude and longitude of American extremes and within parallels of paradox." The book contains interesting discussions of climate, people, history, myths, problems, politics, institutions, virtues, defects, successes and failures of the American Midlands, both rural and urban.—F.D.F.

Dr. H. C. Allen, for the past thirty-six years in charge of courses in analytical chemistry at the University of Kansas and a life member of the Kansas Academy of Science, reached the retirement age this past year and in June, 1946, became emeritus professor.

Dr. J. R. Berg, subsurface geologist with the Shell Oil Company, has resigned from that position to become associate professor of geology on the University of Wichita faculty. A native of Chicago, Ill., Dr. Berg is a graduate of Augustana College, Rock Island, Ill., and received his doc-

torate from the State University of Iowa. From 1942 to 1944, he worked as chemical engineer for DuPont and joined the Shell company in 1944.

Dr. Martha S. Pittman, head of the department of food economics and nutrition, Kansas State College, Manhattan, since 1919, has reached the retirement age for administrative officers and will be succeeded by Dr. Gladys E. Vail who has been a member of the department since 1927.

Dr. Max Dresden, who has been teaching for the past three years at the University of Michigan, becomes acting assistant professor of physics at the University of Kansas. Dr. Dresden, a specialist in the field of quantum mechanics, received his doctorate from the University of Michigan.

Miss Margaret Newcomb who has held a Rockefeller Foundation fellowship in botany at Indiana University for the past two years, resumes her work as associate professor of botany, Kansas State College, Manhattan, with the beginning of the fall semester.

Dr. John A. Shellenberger, head of the department of milling industry, Kansas State College, Manhattan, left Manhattan on July 2 for Peru. Dr. Shellenberger's trip was made at the request of the office of Foreign Affairs, Washington, D. C. in an effort to aid Peru in solving her food shortage problems, one of the chief of which is the raising and milling of more grain. Dr. Shellenberger spent over two months on the mission.

Miss Helen P. Hostetter, editor of the *Journal of Home Economics,* Washington, D. C., has been named professor of journalism at Kansas State College Manhattan. Miss Hostetter will, among other duties, teach courses in the new curriculum recently established by Kansas State in home economics and journalism. She is a graduate of Kansas State College, the University of Nebraska and Northwestern University and in addition to her extensive editorial work has had previous teaching experience at Kansas State, as well as at Lingnan University, Canton, China.

Dr. Luther L. Lyon recently joined the staff of the University of Wichita Foundation for Industrial Research as research chemist. He is specializing in problems of a colloidal chemical nature for the Foundation and in addition is teaching a course in this field for the University's chemistry department. Dr. Lyon was graduated from Southwestern College in 1939. He obtained his A. M. degree from the University of Kansas in 1941, and his Ph.D. from the University of Southern California in 1944. While at the University of Kansas, he was assistant instructor in the department of chemistry. At Southern California he worked under a research fellowship in colloid chemistry and did part-time teaching. From 1944 to 1946 he served in the United States Navy as a commissioned officer.

Among the 32 promotions at Kansas State College during the past summer were included the following individuals, many of whom have been prominent in the work of the Academy. The *Transactions* extends its heartiest congratulations to all.

Associate professor to professor: L. P. Reitz, *agronomy;* K. L. Anderson, *agronomy;* V. D. Foltz, *bacteriology.*

Assistant professor to associate professor: Earl D. Hansing, *botany and plant pathology;* Stuart M. Pady, *botany and plant pathology;* J. C. Bates, *botany and plant pathology;* Madalyn Avery, *physics;* J. R. Chelikowsky, *geology.*

Instructor to assistant professor; J. O. Harris, *bacteriology;* T. H. Lord, *bacteriology;* F. C. Lanning, *chemistry;* A. M. Guhl, *zoology.*

Dr. T. D. A. Cockerell, honorary member of the Academy and author of "The Colorado Dessert" appearing in the June, 1945, issue of the *Transactions,* will leave this fall to spend the winter in Honduras. Dr. Cockerell, accompanied by Mrs. Cockerell, will spend six months studying the insects of Honduras at the Escula Agricola Panamericane, Tegucigalpa.

Dr. L. D. Bushnell, past president of the Academy, and head of the department of bacteriology, Kansas State College, Manhattan, has reached the retirement age for administrative officers and will be succeeded by Dr. P. L. Gainey as head of the department. Dr. Bushnell will continue his teaching duties.

Thirty-four students, a record number, were in attendance at the University of Kansas field geology school at Garden Park, Colorado, this past summer. The six weeks' term at the school was in charge of Dr. J. C. Frye, director, and Mr. A. L. Bowsher, graduate assistant. The University field school is located 15 miles north of Canyon City and its facilities are gradually being enlarged. At present, the plant consists of 4 dormitory cabins, an instructor's cabin, a recreation and study hall, and a staff house.

Mr. Wayne Simmonds, 29-year-old war veteran and graduate student in the University of Wichita botany and bacteriology department, was credited this summer with the discovery of a new strain of penicillium. Simmonds' discovery, announced to the public in June, rewarded a year's research with disease-producing fungi isolated from cases in the Wichita area. Simmonds is now pursuing further research in this field at the University of Southern California School of Medicine where he is working under a laboratory associateship.

Dr. Clair A. Hannum of Seattle, Washington, was recently appointed associate professor of zoology at the University of Wichita. He served in the South Pacific as a parasitologist with the U. S. Army during the war. He obtained his B.S., M.S., and Ph.D. degrees from the University of Washington.

Mr. J. C. Frankenfeld of the U. S. Bureau of Entomology and

Plant Quarantine, Manhattan, was in charge of tests of insects and seeds following the first atomic explosion at Bikini Atoll. Mr. Frankenfeld was absent from Manhattan for two months while making the tests.

Among promotions announced at the University of Kansas for the school year 1946-47 were those of Dr. R. M. Dreyer who becomes associate professor of geology and Dr. James Coleman who becomes assistant professor of psychology. Dr. Albert Spaulding becomes assistant professor of sociology in charge of courses in anthropology.

Dr. J. W. Greene, head of the chemical engineering department, Kansas State College, Manhattan, has resigned his position to accept a similar one at the University of Denver. Dr. Greene began his service at Kansas State in 1937. Dr. Greene will be succeeded at Manhattan by Dr. F. A. Rohrman, since October, 1945, associate professor of chemical engineering. Before accepting the Manhattan position, Dr. Rohrman was lieutenant colonel in the U.S.A. in command of an artillery battalion. Dr. Rohrman has also had ten years of teaching experience at Michigan State College of Mining and Technology.

Dean L. E. Call, recently retired from his administrative post at the school of agriculture, Kansas State College, Manhattan, will be honored by a presentation portrait to be executed by the artist, Othmar Hoffler. The portrait when completed, will be hung in East Waters Hall.

Dr. Donald F. Hoffmeister, for the past two years assistant professor of zoology at the University of Kansas, has resigned his position to accept a similar one at the University of Illinois. Dr. Hoffmeister begins his new duties with the opening of the fall semester.

Dr. W. H. Schoewe of the State Geological Survey and department of geology, University of Kansas, was guest faculty member at the Kansas Layman's Camp held July 25-28 at Camp Wood near Elmdale, Chase County, in the Flint Hills country. The Kansas Layman's Camp is sponsored by the Y.M.C.A. and was attended by about 100 business men and Y.M.C.A. leaders from over the state. In addition to three lectures given on the topography, geology and mineral resources of Kansas, Dr. Schoewe conducted short geologic field trips on two afternoons while at Camp Wood.

Mr. Carl W. Bartholomai has been appointed to assist Mr. H. H. Walkden of the U. S. Bureau of Entomology and Plant Quarantine, Hutchinson, in the investigation of the southwestern corn borer.

Mr. Frank Miller, Jr., who received the master of science degree at Kansas State College, Manhattan, in June has been appointed bee inspector for the state by the Kansas Entomological Commission. This position, a full-time one, has just been es-

tablished and will be under the direction of Dr. R. L. Parker, state apiarist.

Dr. Thomas Castonguay and Dr. Lloyd Berg, both associate professors of chemical engineering at the University of Kansas, have resigned their positions to accept headships of chemical engineering departments in other universities. Dr. Castonguay at the University of Kansas since 1940 goes to the University of New Mexico, Albuquerque, and Dr. Berg, at the University since April, 1946, goes to the University of Montana, Missoula.

Dr. Carroll W. Bryant, professor of physics, resigned from the University of Wichita faculty this summer to return to the research and experimental section of the Army Air Forces, with headquarters at Langley Field, Va. Dr. Bryant worked with the operations analysis section of the air forces during the war and for some time was stationed in the North African and Mediterranean sector. His new appointment involves work of a similar nature.

Professor D. Ruth Thompson of the department of chemistry, Sterling College, was a member of the chemistry department staff, teaching general chemistry, at Denver University during the past summer.

Dr. H. T. U. Smith of the department of geology, University of Kansas, has returned to his duties at the University this fall, after 3 years spent with the military geology section, U.S.G.S., Washington, D. C.

Dr. M. L. Thompson, associate professor of geology, University of Kansas, has resigned his position to accept a similar one at the University of Wisconsin, Madison.

Dr. Robert V. Christian, Jr., 1940 graduate of the University of Wichita, has returned to his alma mater as assistant professor of chemistry. He has been on the staff at Iowa State College since leaving Wichita and obtained his doctorate there this summer. His special field is analytical chemistry.

Mr. M. J. Caldwell, since 1932 a member of the chemistry department staff, Kansas State College, Manhattan, has resigned his position to accept a place on the staff of the Missouri School of Mines, Rolla.

Recent additions to the staff at Kansas State Teachers College, Pittsburg, include the appointment of Dr. Theodore M. Sperry and Miss Ruth Moon as assistant professors of biology and Mr. Eugene Dawson as assistant professor of psychology and philosophy. Dr. E. O. Price, assistant professor of chemistry, has resigned to accept a position in the chemistry department at Alabama Polytechnic Institute at Auburn. Dr. L. C. Heckert, who was on leave of absence doing defense work with the Jayhawk Ordnance Plant during the war, has returned to resume his position as head of the department of physical science. Professor R. W. Hart has also returned to his position as professor of mathematics after spending the war years in the United States Navy.

Professor W. H. Matthews of the department of physical science, Kansas State Teachers College, Pittsburg, has been appointed assistant field representative for the United States Office of Education to help in the procurement of surplus war materials for the schools of Kansas. He will continue his work at the College where he is coordinator of veteran affairs in addition to his teaching responsibilities.

Miss Eva McMillan, associate professor of food economics and nutrition, Kansas State College, has returned to her duties at Manhattan after an 11 months' leave spent in Brazil. Miss McMillan assisted, during her leave, in the establishment of a home economics department in the Colegio Americano, Porto Alegre, Brazil.

The formation of a department of geology at Kansas State College, Manhattan, has been recently announced. Professor A. B. Sperry, since 1921 a member of the Kansas State staff, is head of the new department which includes the following new members: Oscar W. Tollefson, assistant professor; Lewis Riseman, Margaret H. Smith, and Sara C. Larson, instructors.

Recent publications of the State Geological Survey, University of Kansas, include:

Bulletin 62, *Exploration for Oil and Gas in Western Kansas During* 1945 by Walter A. Ver Wiebe, June, 1946, 112 pages, 31 figures (with one exception, the figures are maps), 25 cents.

Bulletin 64, Part 2, *Silicified Rock in the Ogallala Formation* by John C. Frye and Ada Swineford, July 1, 1946, pages 37-76, map and 8 tables, 10 cents.

Bulletin 64, Part 3, *Ground-Water Conditions in Elm Creek Valley, Barber County, Kansas* by Charles C. Williams and Charles K. Bayne, September, 1946, pages 81-124, 9 figures and 2 plates, 10 cents.

Copies of the above publications may be obtained by addressing the State Geological Survey, Lawrence, Kansas, for mailing charges as indicated above.

Natural History in An Earlier Day

About a year before I came out of the country [Virginia], as I was coming down Rapahannock River in a Sloop bound for the Bay, 3 Leagues short of the River's mouth, being left alone in the Sloop, I heard a great Rushing and Flashing of the Water, which caused me suddenly to look up, and about half a Stone's Cast from me appeared a most prodigious Creature, much resembling a Man, only somewhat larger, standing right up in the Water, with his Head, Neck, Shoulders, Breast, and Waist, to the Cubits of his Arms, above Water. His Skin was tawny, much like that of an Indian; the Figure of his head was pyrimidal and slick, without Hair; his Eyes large and black, and so were his Eyebrows; his Mouth very wide, with a broad black Streak on the Upper Lip, which turned upwards at each End like Mustachoes; his Countenance was grim and terrible; his Neck, Shoulders, Arms, Breast and Waist were like unto the Neck, Shoulders, Breast and Waist of a Man; he seemed to stand with his Eyes fixed on me for some time, and afterward dived down, and a little after he rose at somewhat a farther distance, and turned his Head toward me again, and then immediately falleth a little under Water, and swimmeth away so near the Top of the Water, that I could discern him throw out his Arms, and gather them in, as Man doth when he swimmeth. At last he shoots with his Head downwards, by which means he cast his Tail above the Water, which exactly resembled the Tail of a Fish, with a broad Fin at the End of it.—From the *Philosophical Transactions and Collections of the Royal Society*, London, 1749.

Identification of Mammals From Studies of Hair Structure[1]

EARL R. OYER[2]

Fort Hays Kansas State College, Hays

INTRODUCTION

The hair of small and medium sized mammals is often found in the stomachs, feces and pellets of predators; for example in the stomachs and feces of coyotes and in the pellets regurgitated by hawks and owls. In these pellets and feces are the undigested residue of the food these animals have eaten. It is well known that in swallowing their food whole, hawks and owls digest all the tissue except hair, feathers, and bones.

These waste products may be obtained from the nesting and roosting places of these birds of prey and along the trails and near the dens of such mammalian predators as the coyote. If the hair from these sources can be identified, then much desirable information concerning the food of predators can be obtained.

The purpose of this study has been to determine whether or not such identification is possible. It was made in western Kansas during the years 1936 to 1938. Hair samples were obtained from nineteen different species of mammals common to the fauna within a radius of 150 miles of Hays, Kansas.

Little study relative to hair structure for identification purposes has been made by others: L. A. Hausman (see bibliography) has studied the structure of commercial fur-bearing mammals for the purpose of determining economic values of hair; Charles C. Sperry* has studied the hair in the stomachs of coyotes mainly to help identify their food, but he has published nothing on his findings on hair structure.

STUDY OF HAIR

Two types of hair can be distinguished on most mammals, the guard hair and the fur hair. The structure of the two types differs,

---

Transactions Kansas Academy of Science, Volume 49, No. 2, 1946.

[1]Condensation of a thesis submitted to the Graduate Division, Fort Hays Kansas State College, in partial fulfillment of the requirements for the degree of Master of Science.

[2]Acknowledgment is due Dr. L. D. Wooster of the zoology department, Fort Hays Kansas State College, for proposing this study, for his helpful suggestions, and for his photographic work on plates.

*Associate Biologist, Bureau of Biological Survey, Denver, Colorado.

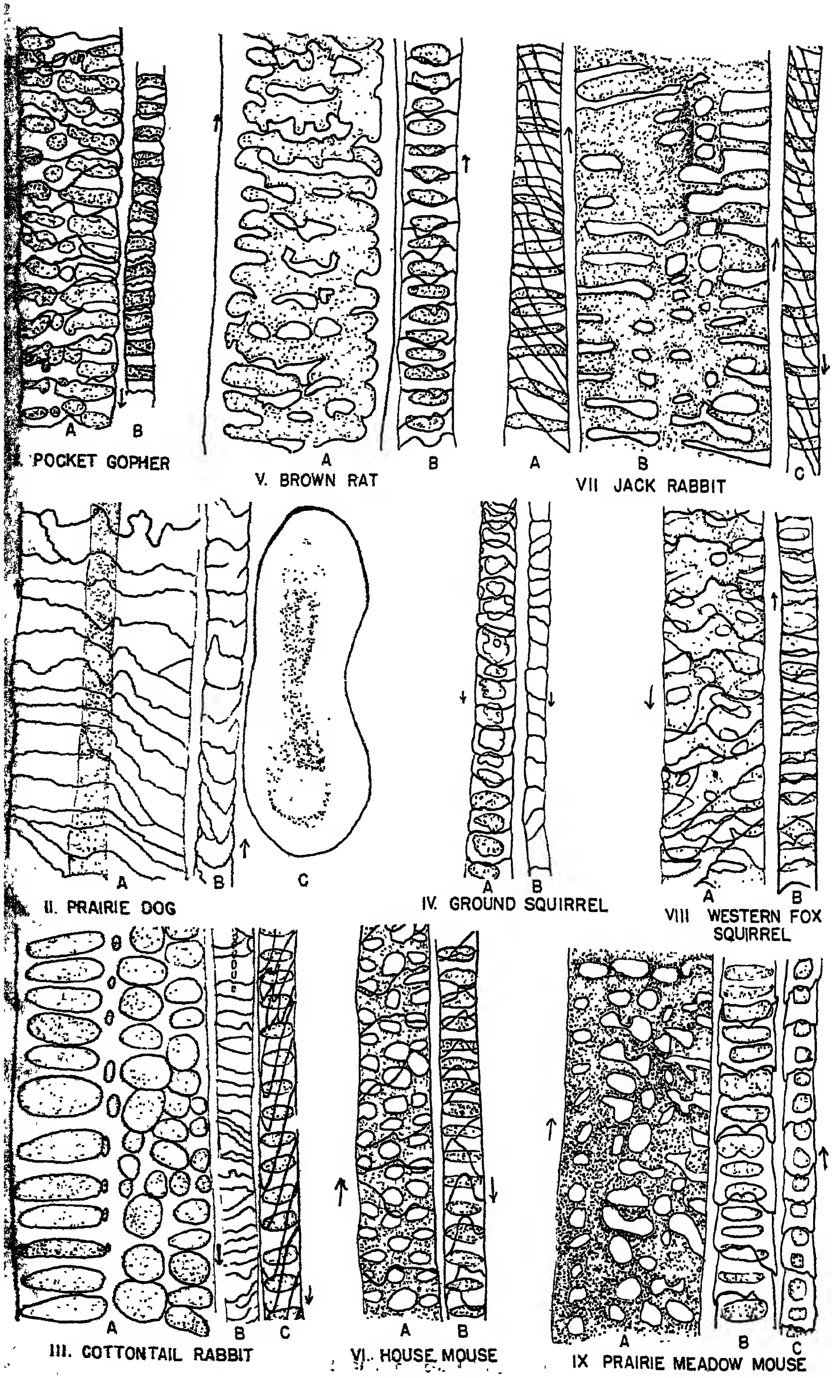

A
B
POCKET GOPHER
A
B
V. BROWN RAT
A
B
C
VII JACK RABBIT
A
B
C
II. PRAIRIE DOG
A
B
IV. GROUND SQUIRREL
A
B
VIII WESTERN FOX SQUIRREL
A
B
C
III. COTTONTAIL RABBIT
A
B
VI. HOUSE MOUSE
A
B
C
IX PRAIRIE MEADOW MOUSE

PLATE 1.

the guard hair being more complex and more significant for identification.

A microscopic study of hair reveals that it is made up on a shaft composed of a medulla (the central core), a cortex layer, and a covering of scales. The medulla appears dark, with portions of it, in most cases, permitting light to shine through. This arrangement helps to give it a definite pattern. A series of scales is found around the cortex layer forming an outside covering of the hair shaft. These scales overlap somewhat like shingles, the free edges of which form a definite pattern. These free edges of the scales point toward the top-end of the hair.

In preparation for this study, samples of hair were pulled from the dorsal region of the kinds of mammals studied, including rabbits, mice, shrews, bats, squirrels, rats, opossums, pocket gophers, and skunks. Each sample was placed in a separate envelope which was carefully labeled with the species' name. Mounts of whole hair were made in balsam on microscopic slides.

These slides were first studied under the microscope for scale structure, but it was difficult to distinguish them by this examination. Various means were tried to bring out scalation patterns and to reduce the amount of pigmentation in the hair shaft. Hair was placed in solutions of various acids and bases; hair was boiled in water; and various stains were used. None of these methods was of

---

I. Pocket Gopher. A, longitudinal section of guard hair of the Pocket Gopher, showing scalation and medulla pattern; B, longitudinal section of fur hair with scale and medulla structure.

V. Brown Rat. A, longitudinal section of guard hair; B, fur hair.

VII. Jack Rabbit. A, longitudinal section of guard hair near root-end; B, longitudinal section of mid-region of guard hair; C, fur hair; D, cross section of guard hair showing medulla.

II. Prairie Dog. A, longitudinal section of guard hair; B, fur hair showing scalation; C, cross section of guard hair.

IV. Ground Squirrel. A, guard hair structure; B, fur hair showing scalation; no medulla is present.

VIII. Western Fox Squirrel. A, longitudinal section of guard hair; B, fur hair.

III. Cottontail Rabbit. A, longitudinal section of guard hair; B, section of guard hair near root-end where medulla begins; C, longitudinal section of fur hair.

VI. House Mouse. A, guard hair; B, fur hair.

IX. Prairie Meadow Mouse. A, longitudinal section of guard hair nearer the tip-end; B, same hair as in A, mid-section where diameter is reduced and medulla becomes discontinuous; C, mid-section of fur hair.

Direction of Arrows. The arrows in both Plate 1 and 2 point toward the root-end of the hair shaft.

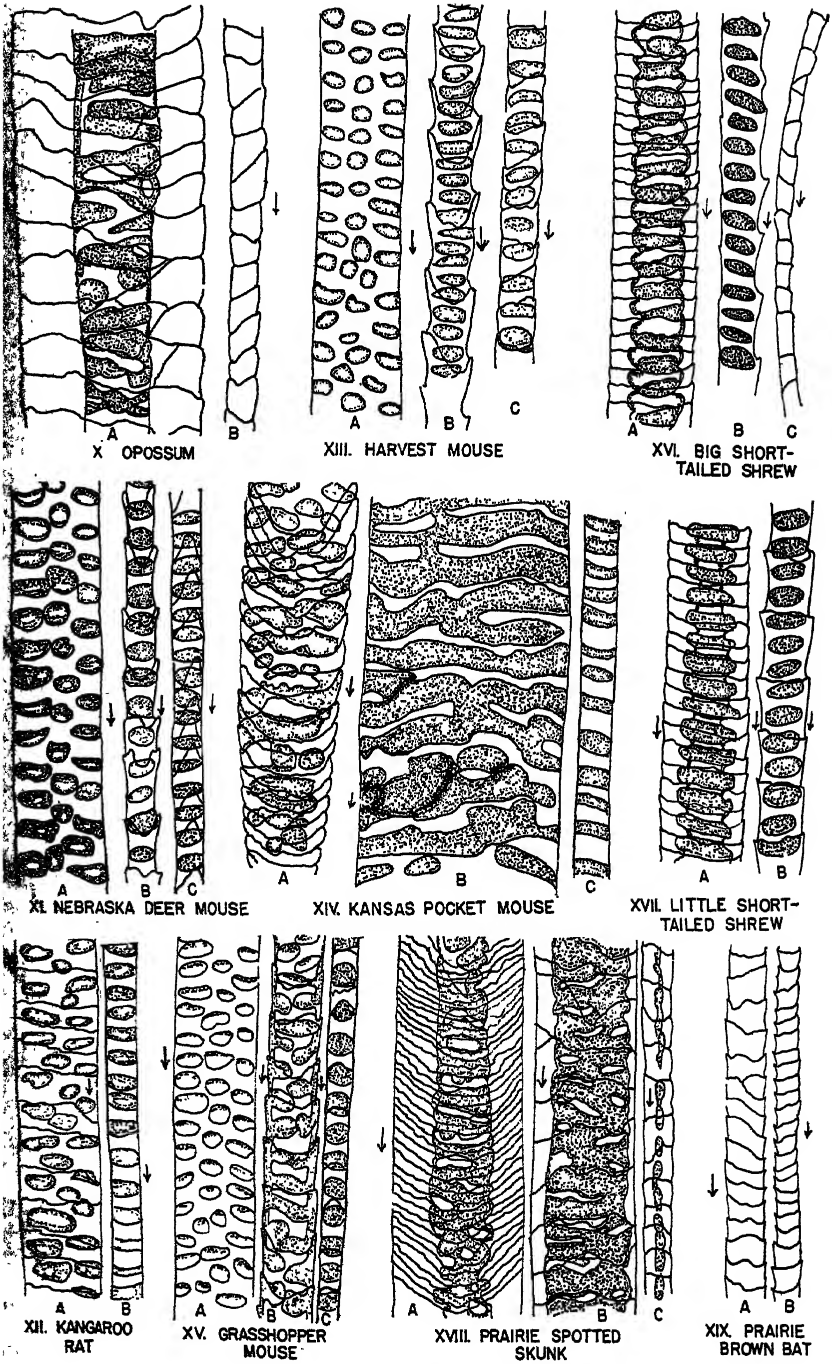

A B
X OPOSSUM
A B C
XIII. HARVEST MOUSE
A B C
XVI. BIG SHORT-TAILED SHREW
A B C
XI. NEBRASKA DEER MOUSE
A B C
XIV. KANSAS POCKET MOUSE
A B
XVII. LITTLE SHORT-TAILED SHREW
A B
XII. KANGAROO RAT
A B C
XV. GRASSHOPPER MOUSE
A B C
XVIII. PRAIRIE SPOTTED SKUNK
A B
XIX. PRAIRIE BROWN BAT

PLATE 2.

much value in bringing out the structure of scales or in changing pigmentation.

After observing a number of dry hairs placed on a slide, it was discovered that some hairs showed the patterns of scale better than others. This difference in appearance seemingly was due partly to the angle from which the light was thrown on the hair. Upon filtering the light with red, green, blue, and amber filters, in various combinations, the amber filter proved the most helpful in bringing out scalation. A piece of amber cellophane was placed over the mirror of the microscope, thus reflecting the amber light on the hair shaft. Variation of the intensity and of the angle of incidence of the amber light proved to be a valuable procedure for discerning scalation.

For each species studied, a dry mount of hair was made by placing a small pinch of hairs on a slide, spreading them, and covering them with a 22x40 mm. cover glass. The edges of the cover glass were cemented on the slide with crystal clear cement thus sealing the hair in an air space. With the use of a camera lucida, a 43 X objective and a 10 X eyepiece, drawings were made from each slide.

X. Opossum. A, longitudinal section of guard hair; B, fur hair with no definite medulla shown.

XIII. Harvest Mouse. A, longitudinal section of guard hair in mid-region; B, the same guard hair showing scalation and medulla near the root-end; C, longitudinal section of fur hair in mid-region showing medulla and scalation.

XVI. Big Short-tailed Shrew. A, longitudinal section of hair at region nearer tip; B, longitudinal section of same hair as in A, but in mid-section in close proximity to narrowed diameter; C, the same hair as in A and B but at narrowest diameter in bend of shaft.

XI. Nebraska Deer Mouse. A, longitudinal section of guard hair at largest diameter nearest tip of shaft; B, longitudinal section of guard hair near root; C, longitudinal section of fur hair.

XIV. Kansas Pocket Mouse. A, longitudinal section of guard hair close to root; B, same hair as in A in mid-region of shaft; C, fur hair showing no definite scales.

XVII. Little Short-tailed Shrew. A, longitudinal section of hair near tip region in the greatest diameter; B, same hair as in A, but in mid-region.

XII. Kangaroo Rat. A, longitudinal section of hair in region of the greatest diameter; B, the same hair as in A showing longitudinal section near tip-end. Only one type of hair is found on this mammal.

XV. Grasshopper Mouse. A, longitudinal section of guard hair at region of greatest diameter, close to tip, showing medulla pattern; B, same guard hair as in A, but closer to root-end, showing scalation and varied medulla; C, mid-section of fur hair showing scalation and medulla.

XVIII. Prairie Spotted Skunk. A, longitudinal section of guard hair in region nearer tip-end; B, section of the same hair in region nearer the root-end; C, longitudinal section of fur hair in region nearer root-end.

XIX. Prairie Brown Bat. A, longitudinal section of hair in mid-region; medulla is absent; B, the same hair as in A but nearer tip-end showing scalation.

RESULTS

Many differences were found in the structure of the hair of the various mammalian species studied, as the accompanying plates show. The differences were sufficient, in most cases to identify a species. Much similarity was found in the structure of hair of four different species of mice, especially the patterns of the medulla of the guard hair.

The structure of the hair of the two kinds of shrews was the most difficult to distinguish.

Each species of mammal does have a definite hair pattern, but this pattern in a few cases is so nearly like that of another species that some other means might be necessary to make a distinction.

Light control as an aid, especially in distinguishing scale patterns, was the most important factor in the microscopic study of hair structure.

BIBLIOGRAPHY

HAUSMAN, LEON A., Recent Studies of Hair Structure Relationships, Scientific Monthly, vol. 30, p. 258-277, March, 1920.

——— Revolutionary New Facts about Hair, Scientific American, vol. 132, p. 98-99, February, 1925.

——— Why Hair Turns Gray, Scientific American, vol. 133, p. 306-307, November, 1925.

WALLING, NORTON C., Your Microscope Reveals Secrets of Hair and Feathers, Popular Science, vol. 126, p. 40-41, June, 1935.

WILLIAMS, CECIL C., A Simple Method of Sectioning Mammalian Hairs for Identification Purposes, Journal of Mammalogy, vol. 15, p. 251-252, August, 1934.

The Age of Needle Leaves

A. E. SHIRLING
National College for Christian Workers, Kansas City, Missouri.

How long do needle-leaves remain active and green on evergreen coniferous trees? We attempted to answer this question one summer during vacation time spent in Estes-Rocky Mountain National Park, Colorado.

Ten species of evergreens were studied and compared with reference to the persistence of their needles. These were:

Western Yellow Pine, *Pinus ponderosa scopulorum*
Lodgepole Pine, *Pinus murryana*
Limber Pine, *Pinus flexilis*
Engelman Spruce, *Picea engelmanni*
Blue Spruce, *Picea pungens*
Douglas Fir, *Pseudotsuga mucronata*
Alpine Balsam Fir, *Abies lasiocarpa.*

Also, a very few specimens of Foxtail Pine, *Pinus aristata,* Pinyon Pine, *Pinus edulis,* and White Fir, *Abies concolor* were sent me from southern Colorado.

Method

Sections were cut through branches and upper part of the boles, or trunks of trees at points where the lowest, oldest, needles were still attached and green. Ages of these sections were determined by counting the rings of growth. Data were collected from each species in different types of environment. Ages of the oldest needles found on different parts of the trees, and in different environments, were tabulated separately, and the average duration of needles for each species was determined. The extent of needle-age variation was determined: (a) for different parts of the same tree, (b) for different trees of the same species, and (c) for different species.

In choosing specimens for study, some attempt was made to cut branches which appeared to have the oldest needles, but this was very uncertain, for *length* of area covered with needles, and *size* of branch or tree had little to do with the ages of the needles.

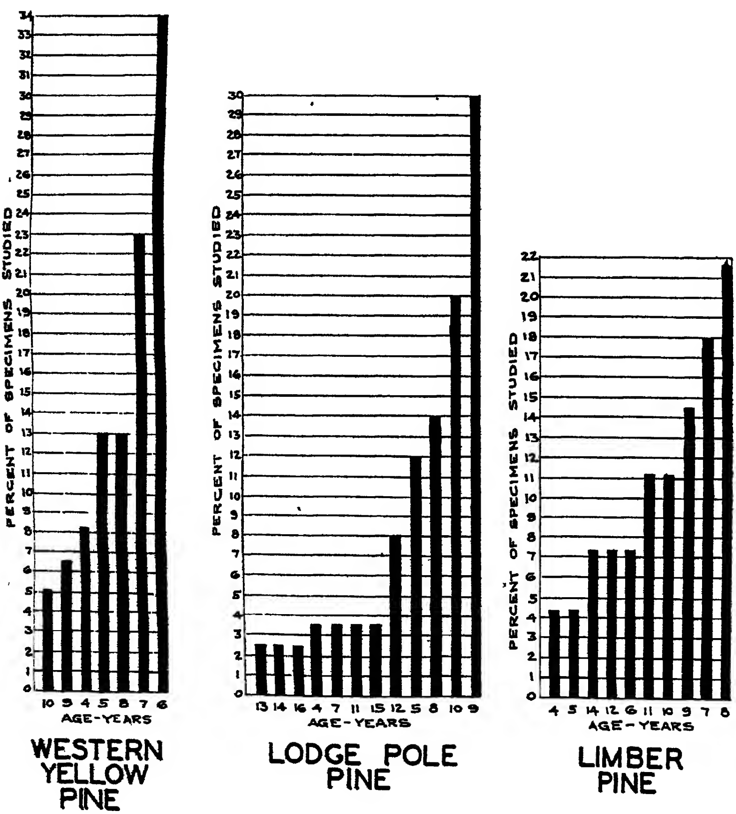
General Results

In young, rapidly growing specimens of Blue Spruce, Engelman Spruce and Alpine Fir, needles on the upper part of the main trunk sometimes extended eight or ten feet below the tip. Cross sections

of such specimens at points of lowest needles were sometimes one to two inches in diameter, yet the ring counts would show ages younger than those of slow-growing needle-covered twigs lower down that were only a few inches long and a fraction of an inch in diameter.

One Lodgepole Pine branch had needles extending six and one-half feet from the tip, and was one inch in diameter at the lowest needle. Other branches, needle-covered for only six inches were as old as the larger branch. One Engèlman Spruce branch, seven-sixteenths of an inch in diameter, was thirty two years old at the

GRAPHS SHOWING PERCENTILE DISTRIBUTION OF AGES OF OLDEST NEEDLES IN CONIFERS STUDIED



lowest needle. We were amazed at the length of life of these needles, and wondered if they might not come from adventitious buds, or needle-producing cambium developing on the branch in more recent years. In this particular branch, however, we were able to get sections showing needle traces very nearly from the center to the outside of the branch, which proved that the needles had persisted for the entire age of the branch. Incidentally, it also indicated that the needle bases grow slowly in length, keeping pace with the increasing diameter of the branch. Such needle traces were usually quite distinct on sections of Limber Pine, and occasionally were well defined on other species.

This thirty two year old section had the oldest needles found during the study. Twenty years was not an uncommon age for needles on Engelman Spruce branches, whose needles extended for a distance of three feet or more below the tips.

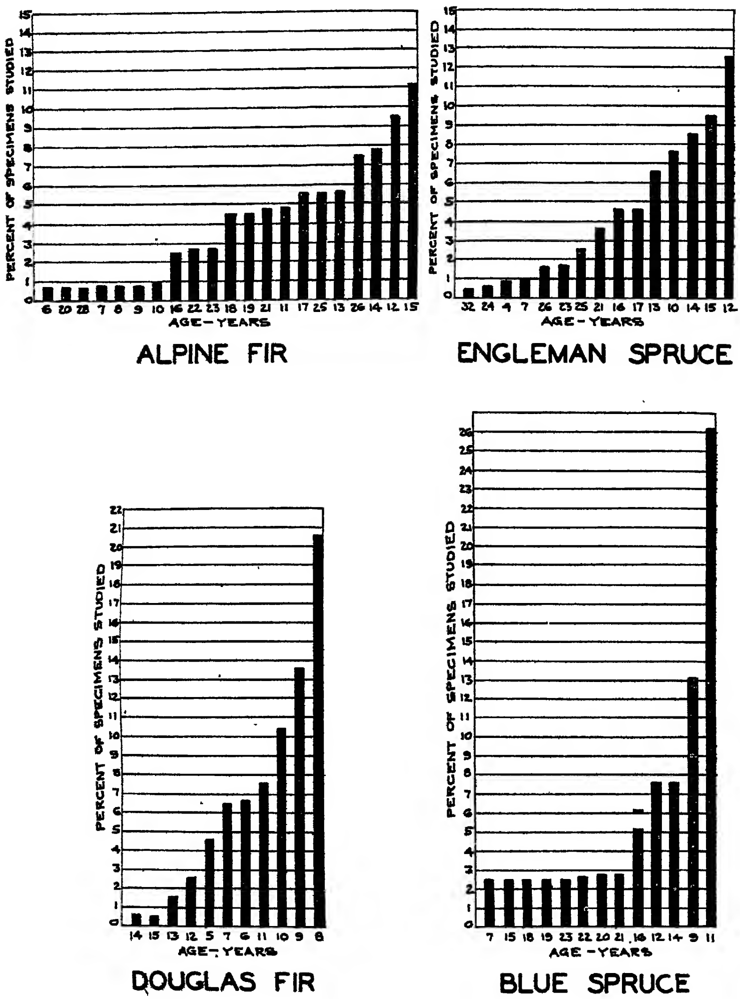
It was difficult to get sections from tops and upper branches of large trees. This was overcome, in a measure, by finding fallen trees and utilizing tops where timber cutting was in operation. Borings were sometimes made to determine ages where it seemed unwise to sacrifice the tops of healthy trees in early stages of maturity.

Another difficulty was in making accurate ring counts. Best results were secured by taking home short pieces, and examining very thin cross sections under a binocular microscope. The rings were very irregular in width in some sections, and it was a question whether those close together represented an entire season or merely part of a season, due to drouth followed by an abundance of rain.

The greatest difficulty was due to the indistinct rings of Limber Pine and the soft, slow-growing twigs of Ponderosa Pine. The rings in these species were often scarcely discernable. We finally discovered, by chance, that sections dipped in kerosene and then dried slightly with a blotter, were greatly improved. The treatment not only differentiated the season's growth by a slight change in color, but also got rid of some of the resinous matter.

There was great variation in the duration of needles on trees at timber line. Branches and tops exposed to the severe wind blasts, plus the shearing effect of ice particles and sand, lost their needles early. In the same environment, but in a protected location, we found branches with needles twenty-five years old. In taking averages these exposed branches were included, which lowered the averages of duration of needles for these species.

GRAPHS SHOWING PERCENTILE DISTRIBUTION OF AGES OF OLDEST NEEDLES IN CONIFERS STUDIED



Summaries for Different Species

Western Yellow, or Ponderosa Pine, *Pinus ponderosa scopulorum.*

Extremes in duration of needles: longest, 10 years; shortest, 4 years, average, 6.7 years.

Rings were indistinct and difficult to count. Ages could sometimes be determined by counting the whorls of needles separated by

the annual rings of bud scales. There was greater uniformity in the life of the needles than in most other species, both as to extremes and as to averages,—only seven years difference between the extremes. Needles persisted longer on trees in the upper part of the species altitude range rather than in the lower, sub-montane regions of foothills.

In comparing a dwarfed, stunted tree growing from a rock crevice beneath the crown of a larger, vigorous tree, with the large tree over-topping it, the needles were more persistent on the stunted one, ages being 7 and 4 respectively. In general, however, with normal trees, rate of growth was no indication of duration of needles.

Lodgepole Pine, *Pinus murryana*

Extremes in duration of needles: longest, 16, shortest, 4 years.

Trees cut for telephone line clearing gave good opportunity for studying ages of needles on upper parts of the tree. This is the only species studied in which needles on the upper part of the trunk persisted longer than on branches. Some attempt was made to compare the ages of needles on stunted trees in a dense stand with more vigorous, dominant trees in the same stand. Slender dwarfs only one or two inches in diameter and five to eight feet high, were compared with those twenty five to thirty feet high and eight to ten inches in diameter. They proved to be approximately the same age,—sixty years. Moreover, the ages of needles were also essentially the same regardless of rate of growth, whether on the upper or lower parts of the tree. Occasionally some branch was found to be extreme, and some variations occured. Averages of six to ten years held for both types of trees. Needles seemed a little less persistent in a moist, sheltered valley (Phantom Valley) on the west slope.

Limber Pine, *Pinus flexilis.*

Extremes in duration of needles: oldest 14, shortest, 4 years.

Rings of growth in Limber Pines were difficult to count. Dipping thin sections in kerosene helped to differentiate them. With the exception of timberline specimens, there was a decided uniformity on ages of needles. The duration of needles was not as long as on the few sections of Foxtail Pine received from southern Colorado.

The Limber Pine has a wider range in altitude in the Colorado mountains than other species, but it does not occur in pure stands.

Engelman Spruce, *Picea engelmanni.*

Extremes in duration of needles: longest, 32, shortest 4 years.

The general average of duration of needles was lowered by including in the counts, specimens taken from top branches at timberline, where trees were swept by blasts of ice and sand. Needles on the west side of the divide ranged slightly older than those on the east slope.

Douglas Fir, *Pseudotsuga mucronata.*

Extremes in duration of needles: longest, 15, shortest 4 years.

There was a decided shorter life of needles on the upper part of the trunk and main leaders, and longer duration on the secondary, or side branches. Persistence of needles was greater on the shaded, protected side of the tree as compared with the side exposed to drying sun.

Douglas Fir in the Rocky Mountains thrives only in northern slopes or in more humid, sheltered valleys. Needles on the north slopes were more enduring than on the southern slopes.

Blue Spruce, *Picea pungens.*

Extremes in duration of needles: longest, 23, shortest 7 years.

Distribution of this species in the Rocky Mountain National Park is confined to humid, sheltered valleys near streams, and at elevations ranging from 6,000 to 9,000 feet. With few exceptions, there is marked uniformity in ages of needles. This may be due to the restricted range. There was little difference in environment in the specimens studied. Rings of growth were quite distinct, and ages easily determined.

A Study of the Production of DDT

THOMAS T. CASTONGUAY and RICHARD L. FERM
Chemical Engineering Department, University of Kansas.

Although considerable private development has been carried out on the preparation of DDT, 1,1,1-trichloro-2,2-bis (p-chlorophenyl) ethane, little data on the production of this compound has appeared in the literature. The classic and original synthesis by Zeidler[12] in 1874 is used as a basis for present day commercial production.

Directions for the preparation of DDT on a laboratory scale by the condensation of chloral, or chloral hydrate, with chlorobenzene using sulfuric acid as a catalyst have been given by Zeidler,[12] Müller,[10] Hughes, [7,8] Iris and Leyva,[9] Bailes, [1] and Darling.[3] Rueggeberg and Torrans[11] have used chlorosulfonic acid in place of sulfuric acid. In 1943 Brothman and Barish[2] designed a pilot plant for the continuous production of DDT using chloral, oleum, and an excess of chlorobenzene. Several different isomers are possible. According to Gunther,[5] technical DDT produced by the Brothman continuous process contains 70% of the p,p′-isomer, 18% of the o,p′-isomer, and 6% of the o,o′-isomer, the balance being ash, volatile, and unidentified material. The composition of technical DDT has been studied by Haller and co-workers.[6]

Procedure

The object of this paper is to show the general effect of changing such variables as strength of sulfuric acid, amount of acid, temperature, reaction time, and the amount of excess chlorobenzene on the yield of crude DDT prepared by the condensation of chloral with chlorobenzene using sulfuric acid as a catalyst. Both the composition of the sulfuric acid and the amount used were expressed by a factor called "the dehydrating value of the sulfuric acid, D.V.S." This factor is usually obtained by dividing the weight of 100% sulfuric acid used by the total weight of water that would be present if the reaction were 100% complete. This weight of water includes any uncombined water in the original acid or any of the reactants.[4] However, since fuming sulfuric acid was used, the D.V.S. factor in this paper was obtained by dividing the sum of the weights of combined and free sulfur trioxide present by the sum

of the weights of combined and free water present at the end of the reaction assuming 100% reaction.

The chloral used was prepared as follows: Chloral hydrate (100 grams) was mixed with 97.1% sulfuric acid (30 to 40 ml.), allowed to stand for 24 hours, and separated by means of a separatory funnel. The chloral thus obtained was allowed to stand several hours over a layer of 97.1% sulfuric acid. After separation from the acid it was mixed with a small amount of additional acid (10 ml. of acid to 100 ml. of chloral) and distilled. The fraction boiling between 96 and 98°C. was collected. The chloral thus prepared had an index of refraction of 1.4557 at 28°C.

All reactions were carried out in the following manner. 14.74 grams (0.1 mole) of chloral, 67.7 grams (0.6 mole) of chlorobenzene, and the required amount of sulfuric acid weighed to the nearest 0.1 gram were mixed together and placed in a 500 ml. three necked flask equipped with a mercury-seal stirrer and a water-cooled reflux condenser. Ice water was circulated through the condenser by means of a centrifugal pump. The reaction mixture was cooled in an ice bath at 0°C., the stirrer started and the reaction mixture stirred at 0° C. for 10 minutes. The ice bath was then removed and the stirring continued for 20 minutes more. At the end of this time the reaction mixture was at room temperature and it was placed in a steam bath and the heating and stirring continued at the desired temperature until the completion of the reaction, in most cases 2 hours. At the end of this time the reaction mixture was allowed to cool to room temperature, was poured into crushed ice, and allowed to stand overnight. The mixture was then filtered and the residue freed from excess chlorobenzene and water by either vacuum stripping or steam distillation. The latter method was used in all but experiments 2 to 11 and 26 because it gave a white crystalline solid immediately upon cooling the residue to room temperature while the method of vacuum stripping gave a product which was a brown, transparent, amorphous gum, which solidified only after standing several days. The products purified by steam distillation were dried at 85°C. for 2 hours, weighed and designated as crude DDT. This crude product, which was cream colored or greyish white in color, gave on recrystallization from 95% ethyl alcohol a white crystalline solid melting at 105-106° C. A second recrystallization raised the M.P. to 107-108°C.

It should be pointed out here that the presence of catalysts would affect the optimum conditions as herein given since it has

been observed that the presence of the tarry residue from previous experiments altered the results obtained considerably.

Effect of D.V.S.

The effect of D.V.S. on the yield of crude DDT at 89°C. and 0°C. is shown in Tables I and II, and Figure 1. The maximum D.V.S. value at 89°C. is about 4.6 and at 0°C. about 4.3. A D.V.S. of 4.44 corresponds to a residual acid of 100% sulfuric acid after completion of the reaction.

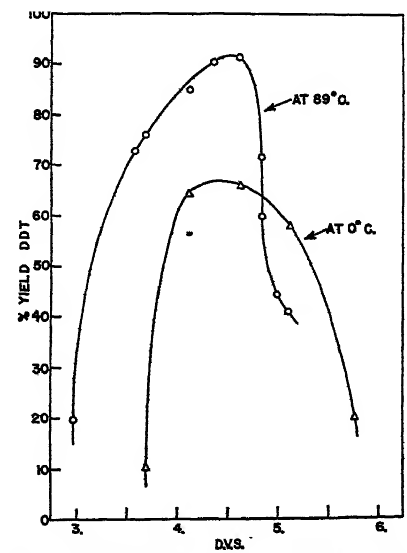


Fig. 1. Effect of D.V.S. on Yield of Crude DDT.

The products from experiments 11 to 14 melted between 86 and 91°C. The product from experiment 15 however, melted from 100 to 110°C. Because of this high melting point, which indicated that this product might not be crude DDT, the stability of DDT in 97.1% sulfuric acid, 100% sulfuric acid, and fuming sulfuric acid containing 24.0% free SO_3 was determined. A 0.5 gram sample of DDT (M.P. 105-106°C.), obtained by recrystallizing one of the products from a previous experiment from 95% ethyl alcohol, was mixed with 10 ml. of 97.1% sulfuric acid, and heated to 60°C. for one hour. The mixture was then diluted with 75 ml. of distilled water. A white solid precipitated which was filtered, dried, and weighed. It weighed 0.4 gram, had a melting point of 105-106°C., and gave a mixed melting point with the original sample of 104-105°C. A 0.5 gram sample of DDT was treated with 100% sulfuric

TABLE I.—Effect of D.V.S. on Yield of Crude DDT at 89°C.

Exp.	H_2SO_4 Mixture grams	D.V.S.	Yield of Crude DDT %	Chlorobenzene Recovered ml.
1	100.0 A 4.0 water	2.99	19.8	51
2	138.0 A	3.61	72.3	5
3	200.0 A	3.69	76.0	2
4	100.0 A 50.0 C	4.13	85.3	0.5
5	50.0 A 50.0 C	4.36	90.4	0.5
6	50.0 A 75.0 C	4.62	91.9	1
7	50.0 A 100.0 C	4.84	72.1	0.2
8	50.0 A 100.0 C	4.84	60.1	trace
9	50.0 A 125.0 C	5.00	44.8	0.2
10	200.0 C	5.78	---- --	---- --

A=grams of 97.1% sulfuric acid.
C=grams of oleum (24.0% free SO_3).

acid. The solid which was recovered weighed 0.47 grams, had a melting point of 104-105°C., and gave a mixed melting point with the original sample of 104-105°C. A sample of DDT was treated with fuming sulfuric acid containing 24.0% free SO_3. The reaction mixture was completely soluble when diluted with water. These ex-

TABLE II.—Effect of D.V.S. on Yield of Crude DDT at 0°C.

Exp.	H_2SO_4 Mixture grams	D.V.S.	Yield of Crude DDT %	Chlorobenzene Recovered ml.
11	200.0 A	3.69	10.3	49
12	100.0 A 50.0 C	4.13	64.6	46
13	50.0 A 75.0 C	4.62	66.3	27
14	50.0 A 150.0 C	5.11	58.3	5
15	200.0 C	5.78	---- --	---- --

A=grams of 97.1% sulfuric acid.
C=grams of oleum (24.0% free SO_3).

periments show that DDT is stable in 97.1% or 100% sulfuric acid but is not stable in fuming sulfuric acid containing 24.0% free SO_3.

EFFECT OF AMOUNT OF ACID

The effect of varying the amount of acid on the yield of crude DDT at constant D.V.S. is shown in Table III. Since the maximum yield in previous experiments was obtained with a D.V.S. of 4.44 or when the residual acid at the end of the reaction was 100% sulfuric acid, the D.V.S. in experiments 16 to 21 was kept constant at 4.44 by adding 33.3 grams (0.1 mole SO_3) of 24% oleum which was just enough to react exactly with the 0.1 mole of water liberated by the condensation of 0.1 mole of chloral. The amount of acid was varied by adding different weights of 100% sulfuric acid in each experiment.

TABLE III.—Effect of Amount of Acid on Yield of Crude DDT.

Exp.	H_2SO_4 Mixture grams	Strength of Initial acid in free SO_3—%	Temperature °C.	Grams 100% Acid per ml. Other Reactants	Yield of Crude DDT %	Chlorobenzene Recovered ml.
16	33.3 C	24.0	63	0.49	42.6	45
17	20.0 B 33.3 C	17.6	62	0.77	76.8	30
18	35.0 B 33.3 C	13.3	60	0.98	81.2	28
19	50.0 B 33.3 C	10.6	71	1.19	89.5	23
20	100.0 B 33.3 C	6.4	69	1.89	92.6	9
21	200.0 B 33.3 C	3.6	66	3.29	95.1	0.1

B=grams of 100% sulfuric acid.
C=grams of oleum (24.0% free SO_3).

To show the effect of these different acid mixtures on the yield of crude DDT, a relationship between the weight of acid and the volume of the other reactants used was calculated. The grams of 100% sulfuric acid present at the end of the reaction were divided by the sum of the volumes of all the other reactants as initially added to the reaction mixture. In Figure 2 the per cent yield of crude DDT is plotted against the grams of 100% sulfuric acid per ml. of other reactants. The curve shows that the D.V.S.—yield relationship

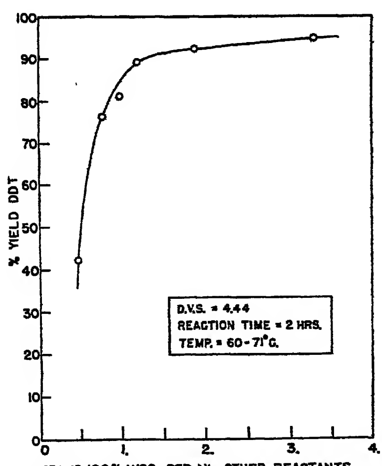


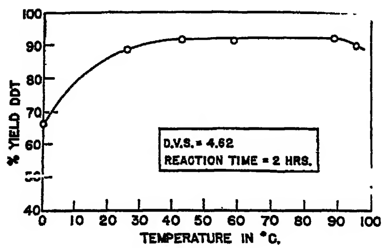
Fig. 2. Effect of amount of Acid on Yield of Crude DDT.

holds very well when the grams of acid per ml. of other reactants is 1.19 or above; below this value the yield of crude DDT falls very rapidly. The low yield of DDT in those cases where the original acid was of high SO_3 content was not due to the consumption of chlorobenzene by sulfonation because most of the excess chlorobenzene was recovered in the purification process. All the products

were purified by steam distillation giving in every case a white solid which melted within the range of 85-91°C. Although there was some variation in the temperature of these experiments it will be shown in later experiments that this variation does not affect the yield of crude DDT.

Effect of Temperature

The effect of temperature on the yield of crude DDT is shown in Table IV and Figure 3. The D.V.S. (4.62) and the amount of acid used (50.0 grams of 97.1% sulfuric acid and 75.0 grams of oleum containing 24.0% free SO_3) were kept constant in all these



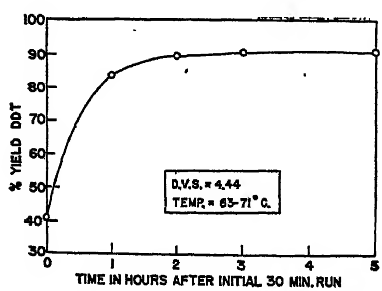


Fig. 3. Effect of Temperature on Yield of Crude DDT.

Fig. 4. Effect of Reaction Time on Yield of Crude DDT.

experiments. The products, purified by steam distillation, all melted within the range of 84-91° C. The curve, Figure 3, shows that a temperature between 40 and 90° C. is necessary for a satisfactory reaction but that within this range the yield is independent of temperature. The yield falls off slightly when the temperature is increased above 90°C. Temperatures above 97°C. were not tried because the product became more discolored the higher the temperature above 90° C.

Table IV.—Effect of Temperature on Yield of Crude DDT.

Exp.	Temperature °C.	Yield of Crude DDT %	Chlorobenzene Recovered ml.
22	0	66.3	27
23	26	88.4	19
24	43	91.7	16.5
25	59	91.0	8
26	89	91.9	1
27	97	89.1	0

Effect of Reaction Time

The effect of reaction time on the yield of crude DDT is shown in Table V and Figure 4. The D.V.S. (4.44) and the amount of

Table V.—Effect of Reaction Time on Yield of Crude DDT.

Exp.	Time After Initial 30 Min. in Hr.	Temperature °C.	Yield of Crude DDT %	Chlorobenzene Recovered ml.
28	0	xx	41.0	41
29	1	65	83.8	27
30	2	71	89.5	23
31	3	63	90.6	19
32	5	67	90.9	18

acid used (50.0 grams of 100.0% sulfuric acid and 33.3 grams of oleum containing 24.0% free SO_3) were held constant. All products, purified by steam distillation, were white solids with melting points between 85-91° C. It was found that the yield of crude DDT was increased very little by heating longer than 2 hours at these temperatures.

Effect of Amount of Excess Chlorobenzene

The effect of varying the amount of excess chlorobenzene on the yield of crude DDT is shown in Table VI and Figure 5. An acid

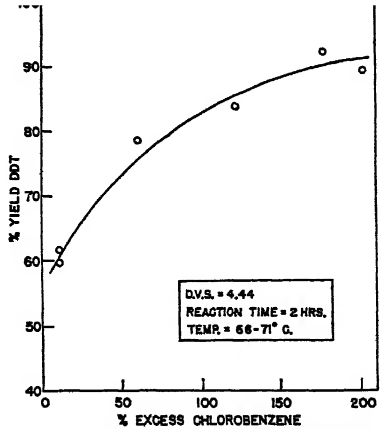


Fig. 5. Effect of Excess Chloroenzeneb on Yield of Crude DDT.

mixture containing 50.0 grams of 100.0% sulfuric acid and 33.3 grams of fuming sulfuric acid (24.0% free SO_3) was used, thus giving a D.V.S. of 4.44. The reaction time was 2 hours. All products, purified by steam distillation, were white solids with melting points between 85 and 91°C. The yield of crude DDT increased with

TABLE VI.—Effect of Excess Chlorobenzene on Yield of Crude DDT.

Exp.	Temperature °C.	Excess Chlorobenzene ml.	Excess Chlorobenzene—%	Yield of Crude DDT %	Chlorobenzene Recovered ml.
33	71	41.3	203	89.5	23
34	89	36.4	179	92.2	7
35	89	25.1	124	83.8	0.4
36	66	12.4	61	78.5	0.5
37	58	2.4	11	61.6	0.4
38	89	2.4	11	59.9	0.1

an increase in the amount of excess chlorobenzene up to and including 179% excess. Beyond this value the yield decreased slightly.

LITERATURE CITED

(1) BAILES, E. L., *J. Chem. Ed.*, 22, 122 (1945).
(2) CALLAHAM, J. R., *Chem. Met. Eng.*, 51, 109-114 (1944).
(3) DARLING, S. F., *J. Chem. Ed.*, 22, 170 (1945).
(4) GROGGINS, P. H., "Unit Processes in Organic Synthesis", 2nd ed., p. 22, New York, McGraw-Hill Book Co., 1938.
(5) GUNTHER, F. A., *J. Chem. Ed.*, 22, 238-42 (1945).
(6) HALLER, H. L., BARTLETT, P. D., DRAKE, N. L., NEWMAN, M. S., CRISTOL, S. J., EAKER, C. M., HAYES, R. A., KILMER, G. W., MAGERLEIN, B., MUELLER, G. P., SCHNEIDER, A., and WHEATLEY, W., *J. Am. Chem. Soc.*, 67, 1591-602 (1945).
(7) HUGHES, R. M., (to J. R. Geigy A. G., Basel, Switzerland) Brit. Patent 547,871 (Sept. 15, 1942).
(8) HUGHES, R. M., (to J. R. Geigy A. G., Basel, Switzerland) Brit. Patent 547,874 (Sept. 15, 1942).
(9) IRIS, R. C., and LEYVA, R. D., *Rev. inst. salubridad enfermedad trop.*, 5, 71-4 (1944); through *C. A.*, 39, 495 (1945).
(10) MÜLLER, P., (to J. R. Geigy A. G., Basel, Switzerland) U. S. Patent 2,329,074 (Sept. 7, 1943); reissue U. S. Patent 22,700 (Dec. 4, 1945).
(11) RUEGGEBERG, W. H. C., and TORRANS, D. J., *Ind. Eng. Chem.*, 38 211-14 (1946).
(12) ZEIDLER, O., *Ber.*, 7, 1180-1 (1874).

Kansas Mycological Notes: 1945[1]

STUART M. PADY, C. O. JOHNSTON,[2] and E. D. HANSING
Kansas State College, Manhattan.

Mycological notes for Kansas were published for the years 1934, 1935, 1936, and 1937 but none have appeared since that time. It seems desirable to revive the series and to record the occurrence of new and interesting fungi in the state as well as any unusual development or distribution of some of the economically important plant pathogens. The plant disease survey work carried on by the U. S. Department of Agriculture from July 1943 to June 1945 under the Emergency Plant Disease Prevention project, in which the senior author served as pathologist, provided a great deal of information on the prevalence and distribution of diseases on cereals. Much of the data concerning the distribution of the fungi on cereal hosts in 1945 has been obtained from this source.

The weather of 1945 was unusual in many respects (see Table I). The winter was mild in most parts of the state with only infrequent and short periods of very cold weather. A large part of the state had a long period of unseasonably high temperatures during the last half of January and first part of February followed by a long cold wet period in March, April, May, and June. Cold wet weather in March and April prevented the seeding of much of the intended acreage of oats. Much of the oats that were sown were put in very late and therefore were late in maturing and were severely attacked by both crown and stem rusts.

TABLE I—Meteorological Data for 1945

	Moisture					Temperature	
	East	Middle	West	State Average	Deviation	Mean	Deviation
Jan.	.62	.93	1.10	.88	+ .19	32.6°	+2.6°
Feb.	1.25	1.06	.43	.91	— .08	35.2	+2.0
Mar.	4.23(+)*	1.43	.23	1.96	+ .51	50.3	+5.9
Apr.	7.68(+)	6.03(+)	3.03(+)	5.58	+2.89	52.0	—2.7
May	5.39(+)	3.38	1.73	3.50	— .31	61.6	—2.3
June	6.80(+)	4.22	3.14	4.72	+ .69	68.0	—5.8
July	4.26(+)	4.25(+)	2.40	3.64	+ .50	77.2	—2.0
Aug.	2.55(—)	1.90(—)	2.60	2.35	— .83	78.5	+0.5
Sept.	7.84(+)	5.04(+)	1.79	4.89	+2.05	69.2	—0.5
Oct.	.97(—)	.87(—)	.60	.81	—1.41	57.4	+0.1
Nov.	.33(—)	.06(—)	.06	.33	—1.05	45.8	+2.5
Dec.	1.11(—)	.88(—)	.45	.81	— .08	27.5	—5.5

*Symbols in parentheses refer to variations from the average monthly rainfall.

A snow storm and low temperatures in the western part of the state in April caused great damage to the winter wheat crop which had already emerged from its dormant winter condition. The full

[1]Contribution No. 477, serial No. 390, Dept. of Botany, Kansas Agricultural Experiment Station.

[2]Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture, with headquarters at Kansas State College.

extent of the damage was not evident until late May and early June when severe lodging and death of many tillers became noticeable.

Rainfall was considerably above normal in the eastern third of the state in every month from March to July, inclusive, and for the whole state in all of those months except May. On the other hand, temperatures were considerably below normal for the period of April to July, inclusive. Thus, the growing season, especially that part related to the growth and maturity of cereals, was marked by an extremely long period of cool wet weather. This favored heavy infections of leaf rusts of wheat, barley, and rye; but temperatures were too low for the rapid development of stem rust. Fortunately, the lower than average temperatures provided a long growing, fruiting, and maturing period for winter wheat and good yields resulted despite extremely heavy infections by leaf rusts in the eastern half of the state. Wet weather in July delayed harvest in some parts of the eastern half of the state and resulted in considerable loss from grain spoilage.

1945 was a "leaf-rust year" for wheat in the eastern half of Kansas. Infections were particularly heavy in south-central counties despite a long cold, wet spring that delayed rust development. During April and the first half of May temperatures were too low for abundant leaf rust infection. In addition wheat was lacking in leafiness and chlorophyll during that period. When temperatures rose and rapid nitrification started, wheat quickly regained its dark green color and leaf rust infection developed very rapidly. Stem rust of wheat was very sparse in 1945 and many fields were practically free from the disease. In fact, stem-rust infection on wheat was lighter than in any year since 1940. However, very heavy stem-rust infection developed on oats during late June and early July. The lateness of the oat crop, due to late sowing caused by wet weather in early spring, favored the development of stem rust and crown rust.

The estimated losses from cereal rusts in Kansas in 1945 are:

Leaf rust of wheat	8 per cent
Stem rust of wheat	trace
Crown rust of oats	16 per cent
Stem rust of oats	12 per cent
Leaf rust of barley	trace
Stem rust of barley	trace
Leaf rust of rye	5 per cent
Stem rust of rye	trace

Heavy leaf rust infections on volunteer and early sown wheat

in western Kansas in the fall of 1944 were not followed by heavy infections in the same fields the following spring. Overwintering was moderate in amount but did not materially affect spring infections.

An unusual phase of the leaf rust disease of wheat in 1945 was the amount of infection on stems and leaf sheaths. In some areas, particularly in Sedgwick County, there were reports of heavy stem rust damage, but an examination of fields revealed only the presence of the teliospore stage of the leaf rust. The presence of the "black stage" of the leaf rust on the stems was mistaken as an indication of the presence of stem rust.

In 1945, the loss due to wheat bunt (*Tilletia foetida*) was estimated at 0.1 per cent, which was the same as the estimated losses recorded in 1943 and 1944. During the last 3 years, bunt has averaged less than at any time since records were first kept on losses in 1917. This decline in loss has been due in part to seed treatment, and in part to earlier planting of wheat under environmental conditions unfavorable for infection. The maximum infection found in 1945 was 20 per cent, in a field of Tenmarq in Phillips County. Bunt was more prevalent in eastern Kansas than in other parts of the state. It was found principally in fields of the variety Clarkan.

Loss due to loose smut of wheat (*Ustilago tritici*) was estimated at 2 per cent in 1945, which was higher than the average loss during the last 10 years. The higher incidence of loose smut in 1944 and 1945 was due principally to above normal precipitation during the latter half of May and early June of the previous year in each case. Frequent rains when the wheat plants are heading are favorable to infection. In 1945, loose smut was highest in eastern Kansas and gradually diminished with decreasing precipitation toward the west. The maximum infection found in any one field was 11 per cent in the variety Red Chief in Sedgwick County.

Losses due to loose smut (*Ustilago avenae*) and covered smut (*U. kolleri*) of oats averaged 1.9 and 0.1 per cent, respectively, with maximum infections of 31 per cent found in a field of Kanota oats in Jewell County. Oat smut was more prevalent in central Kansas than in the eastern or western part of the state.

Brown loose smut (*U. nuda*), black loose smut (*U. nigra*) and covered smut (*U. hordei*) of barley caused losses of 6, 4, and 1 per cent, respectively, with maximum infections of 31 per cent found in a field of Beecher spring barley in Republic County and 33 per cent found in a field of Reno winter barley in Ness County. These 3

species of smut were more prevalent in north central Kansas than in other parts of the state. During the last few years smut has been one of the limiting factors in barley production in Kansas. Many farmers have discontinued growing barley because of these diseases.

Loose smuts of wheat, oats, barley, and rye occasionally were found to attack not only the head, but also the peduncle, upper node, part of the culm below the node, flag leaf and leaf sheath, and with oats and barley, sometimes the second leaf and leaf sheath. These symptoms of smut have been observed for several years in Kansas

Figure 1.—Oat smut on panicles, peduncles, flag leaves and leaf sheaths. The four culms to the left are from the variety Gothland and those to the right are Monarch.

Speckled leaf blotch (*Septoria tritici*) was the commonest and most ubiquitous of the wheat diseases. During the fall, winter, and spring many of the lower leaves were killed by the activity of this fungus. Leaf rust was also a factor in the death of many leaves, particularly in the southern and south central counties. In the northern counties leaf rust was considerably less abundant, whereas speckled leaf blotch was particularly severe. Many fields showed infection not only of the lower leaves, but also of the middle and flag leaves. Some fields where speckled leaf blotch was particularly severe had an estimated 60 per cent loss of leaf surface.

In October 1945, speckled leaf blotch was found on volunteer wheat at the agronomy farm, Manhattan, Kansas, one of the earliest dates it has ever been collected. On October 30 it was observed in an early planted field in Ottawa County just west of Bennington where it had already caused the death of several of the lower leaves. This field had a yellow cast that was evident from a distance.

Data are not available as to the reduction in yield caused by this disease. Studies are in progress at the Experiment Station on this problem. It is now recognized that much of what was previously considered normal winter killing was due to the activities of *Septoria tritici.*

Take-all (*Ophiobolus graminis*) was more severe and widespread on wheat in 1945 than it had been for several years. It was observed in 31 counties grouped for the most part in central Kansas extending as far west as Hodgeman and Ford Counties, to the Nebraska line on the north and to the Oklahoma line on the south. Chase and Riley Counties marked the eastern boundary, although some take-all was found in Wilson and Atchison Counties. The heaviest infections were in Pawnee, Rice, Reno, McPherson and surrounding areas. In Rice County, Hurley Fellows, Division of Cereal Crops and Diseases, U. S. Dept. of Agriculture, made an intensive survey and found take-all in each of the 355 fields examined; 195 showed heavy infection averaging 10 per cent loss, while the remaining fields averaged 2 per cent loss. In most cases the disease appeared as dead areas of various sizes. Later in the season, the "white head" phase of take-all was particularly striking, especially in the northern counties. The loss for the state has been estimated as a trace to 5 per cent.

Black chaff (*Xanthomonas translucens* var. *undulosa*) is normally uncommon on wheat in the state, and when it does appear it is usually on the glumes, as the term implies, where it forms black

spots or stripes. In 1945 infection conditions were favorable for foliage infection and many infected plants were found in Allen and Neosho Counties, in the southeastern part of the state, and in Smith, Jewell, Republic, Washington, and Marshall Counties of north central Kansas. The leaf lesions were long, narrow, pale yellow, and translucent, often showing yellow beads which upon drying formed minute yellowish scales.

Scab (*Gibberella saubinetii*) is normally confined to northeast Kansas, but in 1945 it was found as far west as Jewell County. The heaviest infections were in the area bounded by Republic and Jackson Counties, with some fields having as high as 10 per cent of diseased heads.

Basal glume rot (*Pseudomonas atrofaciens*) was more abundant than usual on wheat in the eastern counties and, like scab, extended westward into some of the central counties. The disease was especially severe on Kawvale in both 1944 and 1945.

Glume blotch (*Septoria nodorum*) was surprisingly scarce in view of the apparently favorable season. It was found on the heads in some fields in eastern Kansas, but infection of the nodes was rare.

Powdery mildew (*Erysiphe graminis*) was present on the lower leaves wherever the growth was heavy and rank.

Anthracnose (*Colletotrichum graminicolum*) was found on the mature stems in one field in Brown County. From Missouri eastward this disease attacks the foliage but no evidence has ever been found of this phase in Kansas. Apparently its appearance on wheat is that of a saprophyte, or weak parasite, attacking the host at the end of the growing season.

A little known disease of wheat, the so-called "yellow spot," which was first reported in the United States in 1942 is also surprisingly prevalent in Kansas. It produces a small black spot with yellow border. Many times the spot is small and the yellow border very narrow but in some varieties the spot is larger and more conspicuous. The cause of this disease is not clear; *Helminthosporium tritici-vulgaris* is considered by some to be the causal agent. While never severe under field conditions, it was present in many fields over the state. It has been found in eastern and central Kansas and as far west as Ford County.

The aecial stage of stem rust (*Puccinia graminis*) on barberry (*Berberis vulgaris*) is very rare in Kansas, partly because conditions usually are unfavorable for over-summering of teliospores and more especially because barberry bushes are uncommon and rarely escape

from cultivation. A large barberry bush, estimated to be 35-40 years old was found to be heavily infected in a farm yard a few miles northwest of Lebanon in Smith County. On May 29th, 1945, most of the pustules showed mature aecia but some still were in the pycnial stage. Between 50-70 per cent of the leaves showed one or more infections. In an attempt to determine the source of this unusual disease, careful surveys were made of the neighboring grain fields and also of the grasses in the vicinity. No wheat fields were closer than ¼ mile and these did not exhibit more than a trace of stem rust. In other words, stem rust was no more severe on wheat in this area than anywhere else in the state. Search for rusted grasses revealed heavy infection on western wheat-grass (*Agropyron smithii*) both on last year's dead stems and this year's (1945) young stems. Cultures[3] from infections on the barberry and on *A. smithii* collected in the vicinity indicated that the aecial infections were the rye race, *Puccinia graminis secalis,* while the grass host harbored the wheat races 56 and 17 of *Puccinia graminis tritici.* While *A. smithii* is known to be a host for the *P. graminis secalis,* this race was not present when the collections were made. It is difficult, therefore, to account for the extraordinarily heavy infection of *P. graminis secalis* on the barberry.

Cereal anthracnose (*Colletotrichum graminicolum*) was found to be causing considerable foliage injury to oats in the southeastern part of the state. This disease, which was reported for the first time in the state on oats in 1944, was also found on various oat varieties in the experimental plots at Manhattan.

Late blight (*Phytophthora infestans*) appeared for the first time in large commercial plantings of potatoes in the Kaw Valley. Wet, cool weather during June undoubtedly was the factor which favored its development. The disease appeared late in June and caused considerable damage to the foliage in individual fields. Concern was expressed over the danger of tuber rot, but warm dry weather during digging effectively checked further development and no evidence of injury from this phase has been reported. Late blight was common in victory gardens from Manhattan east to the Missouri line. This disease was found in western Kansas near Oakland in 1935, and there are reports of its occasional occurrence elsewhere. Although this is the second time the disease has appeared in the state, it is the first time that it has been prevalent. According to

---

[3]Cultures made by the rust laboratory at Univ. of Minn., Univ. Farm, St. Paul, Minn.

Melchers[4] the loss from this disease reduced the crop yield by 10 per cent.

An unusual fungus disease appeared on Chinese elms (*Ulmus pumila*) in various parts of the state. The young twigs and leaves were attacked and turned black very much as if they had been injured by fire or freezing. On the twigs and dead leaves small black fruiting bodies were prominent. The fungus was a species of *Gloeosporium* but was definitely not *G. ulmeum*. *G. ulmicolum* has been reported on the leaves but not as the cause of a twig blight. Specimens sent to J. A. Stevenson of the Mycology and Plant Disease Survey were identified as *G. ulmicolum*. Apparently there are no previous records of this fungus attacking elms in this manner and no previous record for the state. Some specimens on the American elm (*Ulmus americana*) also were received. Favorable weather during the early part of the season was apparently responsible for this outbreak. As the season progressed the dead twigs fell from the tree and warmer dry weather checked any further spread.

The Sycamore disease (*Gnomonia veneta*) was especially severe in the spring of 1945 and every sycamore examined seemed to be heavily attacked. The young twigs and branches were killed early and for a time it appeared as if the trees would not survive. With warmer, drier weather the host gained the advantage and the disease was held in check. The fall of leaves during the summer due to infection was much heavier than usual. On many of the trees on the campus of the Kansas State College die-back of the twigs is causing a mild type of witches' broom.

A serious outbreak of rust (*Puccinia menthae*) on cultivated mint caused a complete loss of the stand of this plant in a garden in Manhattan. There were indications that the rust had become systemic in the plants.

Powdery mildews were prevalent also during the early part of the season. *Erysiphe graminis* on Kentucky bluegrass was conspicuous on lawns and in fields in eastern Kansas not only in the spring but persisting into the fall. Many lawns gave the appearance of having been lightly painted in certain spots. Combined with this was a very heavy attack of leaf rust (*Puccinia epiphylla*) which resulted in very poor growth. Certain areas of bluegrass on the Ottawa University campus had spots 10-15 feet in diameter in which the plants were small due to sparse growth and heavy defoliation. Rose mildew

---

[4] L. E. Melchers. The outcome of the Late Blight of Potato epidemic in Kansas. Pl. Dis. Rep. 29: 673. 1945.

appeared unusually early (in April) and was very severe. Apple mildew (*Podosphaera* sp.) was also observed in the Manhattan area and specimens were also received from Council Grove. Mildew on this host is uncommon.

Shepherd's purse (*Capsella bursa-pastoris*) again was heavily infected with the two diseases, downy mildew (*Peronospora parasitica*) and white rust (*Albugo candida*), the former causing hypertrophy and marked curvature of the stem.

Although phloem necrosis on American elm is not a fungus disease, its rapid spread and increase deserves mention here. Attention was first drawn to this disease when it was officially recognized in 1943 as the cause of the death of many trees in the Kansas City area particularly along the boulevards in Kansas City, Missouri. In 1944 it was found in Kansas City, Kansas, Lawrence, Topeka, and Parsons. During 1945 it was reported from 7 counties along the eastern border, Brown, Atchison, Leavenworth, Franklin, Linn, Bourbon, and Crawford Counties. Reports have come in of suspected trees in areas to the west of this area but so far no positive identifications have been made. A large elm died in Manhattan during the summer with some of the symptoms, but the caramel yellow discoloration of the phloem was lacking. Because of the many inquiries and specimens sent in to the botany department of Kansas State College, a circular has been prepared summarizing our knowledge of this disease up to the present time.

Variable Valence Number*

HARRY H. SISLER
University of Kansas, Lawrence.

The increasing emphasis on the application of the electronic theory of the chemical bond to the interpretation of the phenomena of chemical science has led to the realization that many of the concepts which the classical chemist considered to be both simple and fundamental are neither as simple nor as fundamental as had been believed. The term "valence" is a good example of such a concept. The chemist of 1910 used this term with a great deal of assurance; and although he was at a loss to explain the valency of an element, he did not doubt the fundamental significance of such statements as, for example, that sulfur has a maximum valence of +6, or that manganese has a valence of +7 in permanganates. Now, in these days, when chemists speak of electrons with as great a familiarity as their elders in the profession spoke of atoms, when we deal with ionic bonds, ion-dipole bonds, polar and non-polar covalent bonds, single electron bonds, three-electron bonds, and other even more bizarre and esoteric types of chemical attachments, one no longer feels so secure in speaking of the "valence" of an element. In fact, some leaders in chemical education have advocated outright discard of the term as obsolete, substituting more definite terms such as electrovalence, covalence, and coordination number. This difficulty has been ameliorated, at least, by the use of the admittedly arbitrary but useful term "valence number" or "oxidation state", which in many cases is numerically equal to the "valence" of the element in terms of older definitions. This point has been considered in detail in a previous publication.[1]

The chemists of our father's day were equally glib and self-assured in speaking of elements having "variable valence". Thus, sulfur, nitrogen, chromium, iron, gallium, carbon and many other elements were said to exhibit variable valence, it being implicitly assumed that the factors which account for this phenomenon are of similar nature in each case. The development of the electron theory has shown, however, that variable valence, or rather its modern counterpart, variable valence number, does not arise from a similar cause in the case of each of these elements, but can result from a number of different factors. It is the purpose of this paper to discuss the more important types of variable valence number in terms of the electronic theory.

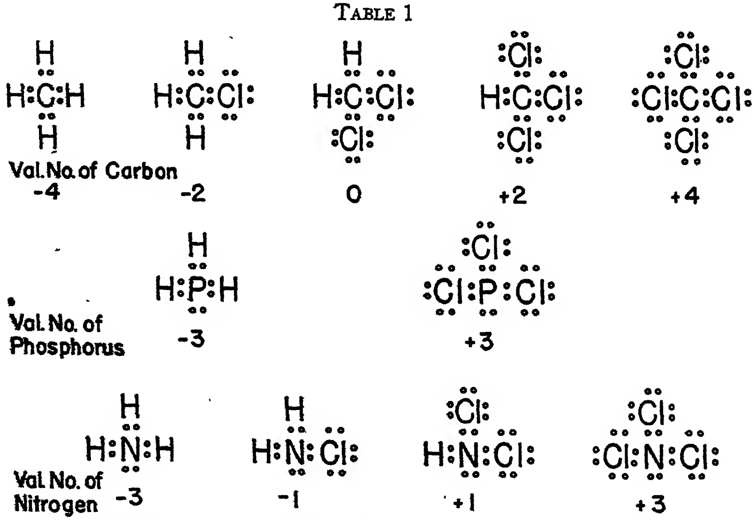
Transactions Kansas Academy of Science, Volume 49, No. 2, 1946.
*Contribution from Bailey Chemical Laboratories, University of Kansas.
[1]Vander Werf, Davidson, and Sisler, J. Chem. Edu. 22, 450 (1945).

Types of Variable Valence.—For the purposes of this discussion, it seems desirable to divide the various examples of variable valence number into the following classes:

(a) Cases involving no difference in the total number of electrons in the shells of the atoms of the element in question and also no difference in the number of electrons which an atom of the element has gained from or lost to other atoms either by sharing or by complete transfer; (b) cases involving no difference in the total number of electrons in the atoms of the element in question but involving a difference in the number of these electrons shared with other atoms; (c) cases involving the difference in the energies of *s* and *p* electrons; (d) cases involving incomplete inner electron shells; and (e) cases wherein the valence shell of the element is expanded from eight to a higher number of electrons. There are, of course, cases in which classification into one of these types would be difficult. Nevertheless, these classes include a great majority of the cases.

Variable Valence Number of Type "a".—As examples of situations involving variable valence number where there is no difference in the number of electrons shared, gained, or lost by the atom in question nor any difference in the total electron content of the atom, we have the several series of compounds given in Table 1.

TABLE 1

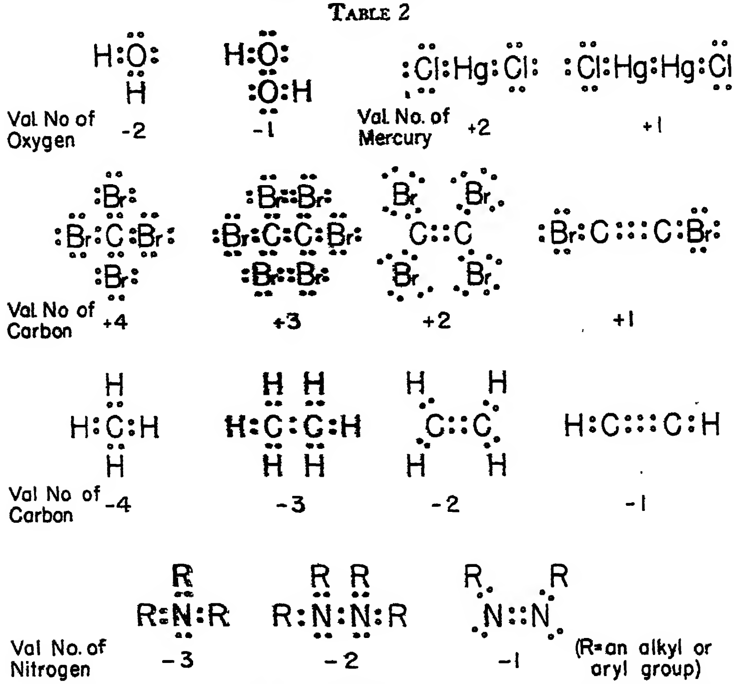


It is obvious from these electronic formulas that there is no difference in either the electron content of the carbon atom or in the number of electrons shared by the carbon atom in the carbon

compounds listed. The same statement is true of the phosphorus atom in phosphine and phosphorus trichloride, and the nitrogen atom in ammonia, chloramine, dichloramine, and nitrogen trichloride. Variable valence number in such cases is apparently a formal difference arising out of the somewhat arbitrary assignment of valence numbers of —1 to the halogen atoms and +1 to the hydrogen atoms. The implications of this fact to the definition of oxidation and reduction have been discussed in a previous publication.[2] This sort of variable valence number is very common in organic chemistry.

Another series of examples of type "a" are listed in Table 2.

TABLE 2



It is apparent in the examples in Table 2 that the variability in valence number arises out of no difference in electron content of the atom in question or in the number of electrons shared by this atom, but rather out of the fact that in going from left to right in each of the horizontal rows an increasing number of electron pairs are shared between atoms of the same element. In terms of the formal rules for determining valence number this behavior results in a decrease in the absolute magnitude of the positive or negative valence number of the element in question.

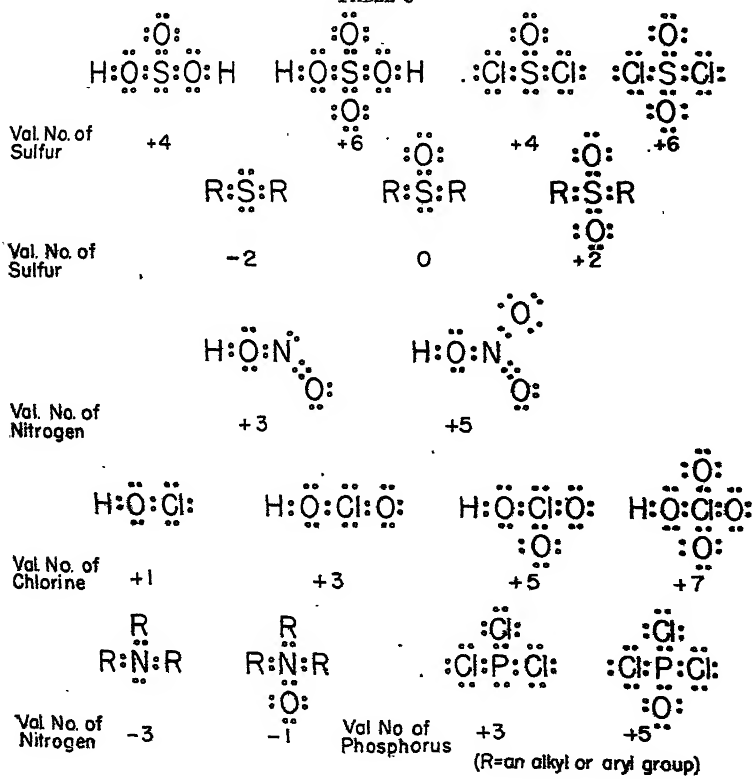
---

[2] Vander Werf, Davidson, and Sisler, loc. cit.

In general, it seems not unreasonable to say that variable valence number of the type represented by the examples in Table 1 involves nothing more fundamental than a slight shift of a pair of electrons toward or away from an atom. In the type of situation represented by the examples in Table 2, the change in valence number involves little more than the sharing of a pair of electrons with an atom of the same element which had formerly been shared by an atom of a different element, or vice versa. Since, in many cases, bonds between like atoms are less stable than between different atoms, differences in valence number of this kind are usually reflected more definitely in the properties of the compounds than are those of the kind illustrated in Table 1.

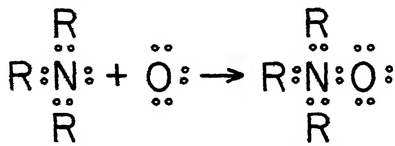
Variable Valence Number of Type "b".—There are a large number of cases of variable valence number which involve nothing more than differences in the number of electron pairs in the valence shell which are shared with other atoms. Examples of such cases are given in Table 3.

TABLE 3

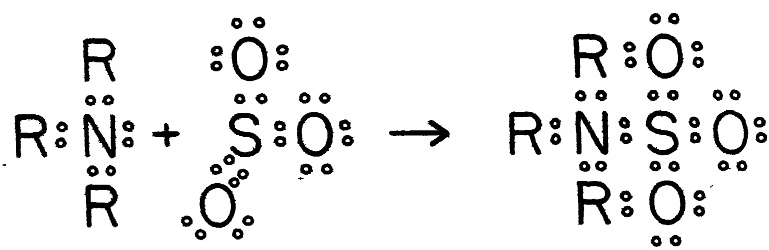


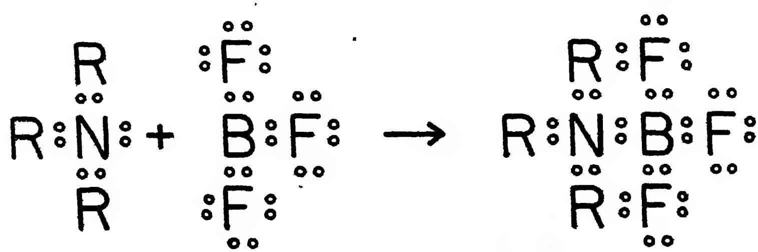
It is in connection with oxidation-reduction reactions involving changes in valence number of the types represented by the examples in Tables 1, 2 and 3 that the definitions of oxidation and reduction in terms of gain and loss of electrons fail.[3]

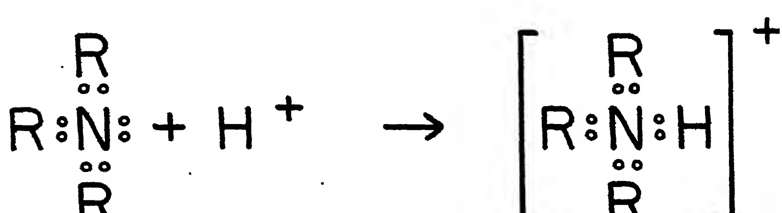
It should be pointed out that the arbitrary character of the definition of valence number sometimes leads to some peculiar and illogical distinctions. For example, according to the definition of valence number, the formation of an amine oxide from an amine, i.e. the coordination of a molecule of the amine with an oxygen atom, changes the valence number of the nitrogen from —3 to —1.



However, the formation of addition compounds of the amine with sulfur trioxide, with boron trifluoride, or with a proton, reactions



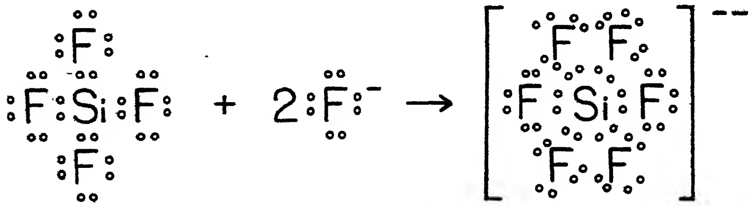


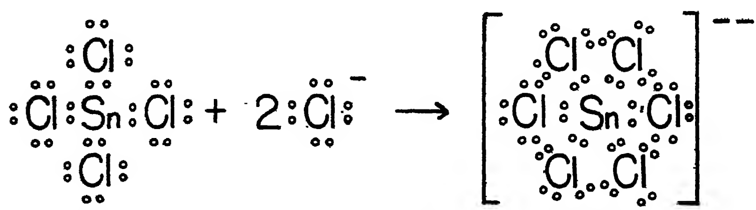


[3]Vander Werf, Davidson, and Sisler, loc. cit.

which are quite analogous to the above, indicated by the equations does not, according to definition, change the valence number of the nitrogen or of any of the other elements in either compound.

In this same connection, it is interesting to note that there are many cases where there is an actual change in the number of electron pairs shared by an atom without, according to the definition, there being any change in valence number; examples include the reactions represented by the following equations:





Such examples as these serve to emphasize the artificiality of the concept of valence number.

Variable Valence Number of Type "c".—Differences in valence number of this type are, in general, of more fundamental significance than those of types *a* and *b*. Because of the greater eccentricity of the orbit of an *s* electron than of a *p* electron in the same shell, the *s* electron penetrates inner shells of electrons to a greater extent than does the *p* electron, and is, therefore, shielded from the nucleus by these inner electron shells to a lesser extent than is the *p* electron. Such an electron is, therefore, more difficult to remove from the atom than the *p* electron.[4]

The result of this effect is that, for atoms in which some of the valence electrons are *s* and some are *p* electrons, it may be possible under certain conditions to remove the *p* electrons without removing the *s* electrons; under other conditions, all the valence electrons may be removed. This means that the atoms will exhibit two valence

[4]Sisler and Vander Werf, J. Chem. Edu. 22, 390 1945).

numbers, one corresponding to the loss of the *p* electrons only, the other to the loss of both the *p* and the *s* electrons. These valence numbers differ by two units, since an *s* subshell contains two electrons, and since this subshell is always filled before any electrons enter the *p* subshell.

A good example of this type of variable valence number is furnished by the elements, gallium, indium, and thallium of the aluminum family, all of which exhibit valence numbers of +1 and +3. All of the elements of the aluminum family, viz. boron, aluminum, gallium, indium, and thallium, have three valence electrons per atom—one *p* electron and two *s* electrons. Ionization potential data for those elements listed in Table 4 show a sharp jump between the first and second ionization potentials as well as between the third and fourth as would be expected from the preceding discussion.

TABLE 4.—Ionization Potentials of the Elements of the Aluminum Family. (Volts).

	1st	2nd	3rd	4th
Boron	8.26	25.00	37.75	258.1
Aluminum	5.96	18.74	28.31	119.31
Gallium	5.97	20.43	30.06	63.8
Indium	5.76	18.79	27.9	57.3
Thallium	6.07	20.32	29.71	......

Monovalent gallium, indium, and thallium are well known and, from the data in Table 4, it might also be expected that aluminum would exhibit a valence number of +1 as well as its common valence number +3. In fact, it has been reported that a monochloride and a monofluoride of aluminum are formed at temperatures above 800°C.

Another example of variable valence number of this same type is furnished by tin and lead which have two *s* electrons and two *p* electrons in the valence shell of each atom and exhibit valence numbers of +2 and +4.

The question might be raised as to the effect of the difference between *s* and *p* valence electrons when electrons are not lost but only shared. Although a rigorous treatment of this point is beyond the scope of this discussion, it should be pointed out that the distinction is, in certain cases, still valid.[5]

Variable Valence Number of Type "d".—The distinguishing characteristic of the transition elements is that their atoms contain a partially filled *d* subshell in the shell underlying the outer electron shell. Electronic configurations of some typical transition elements are listed in Table 5. The partially filled d-subshell is in parentheses in each case.

[5]Pauling, "The Nature of the Chemical Bond," Cornell University Press, Ithaca, New York, 1940, Chap. III.

TABLE 5
3

		s	p	s	p	d	s	p	d	f	s	p	d	s	p
Titanium		2	6	2	6	(2)	2								
Manganese		2	6	2	6	(5)	2								
Chromnum		2	6	2	6	(5)	1								
Rhodium	–	2	6	2	6	10	2	6	(8)		1				
Platinum	2	2	6	2	6	10	2	6	10	14	2	6	(8)	2	

The energies of the electrons in this incomplete *d* subshell do not differ greatly from those in the outer *s* subshell and hence, under some circumstances, these electrons may enter into bond formation. In general the great variability in valence number exhibited by the transition elements is due to the variation in the extent to which this *d* subshell contributes to bond formation, either by releasing or sharing electrons. Thus, chromium exhibits valence numbers of +2, +3, and +6; manganese, +2, +3, +4, +6, and +7; titanium, +2, +3, and +4; platinum, +1, +2, +3, +4, and +6; and rhodium, +1, +2, +3, +4, and +6. There seems to be little regularity as to the valence numbers exhibited by the transition elements, except that in no case does the maximum valence number exceed the total number of electrons in the outer shell plus those in the partially filled *d* subshell. Thus titanium has a maximum valence number of +4, vanadium of +5, chromium of +6, and manganese of +7. According to this same plan iron would have a maximum valence number of +8, cobalt of +9, and nickel of +10, but valence numbers as high as this are not exhibited by these elements; ruthenium and osmium have valence numbers of +8 in the compounds RuO_4, RuF_8, OsO_4, and OsF_8.

The elements of the copper family have, as is shown in Table 6,

TABLE 6

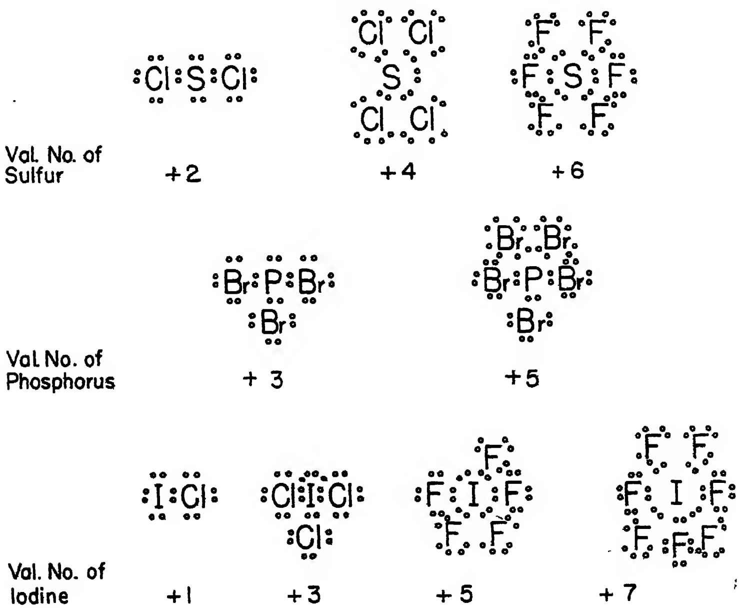
	s	s	p	s	p	d	s	p	d	f	s	p	d	s
Copper	2	2	6	2	6	10	1							
Silver	2	2	6	2	6	10	2	6	10		1			
Gold	2	2	6	2	6	10	2	6	10	14	2	6	10	1

electronic configurations in which the *d* subshell underlying the outer electron shell has reached its capacity of ten electrons. However, this newly completed subshell is still capable of furnishing electrons for bond formation, and each element in the copper family exhibits valence numbers of +2 and +3, as well as +1. In fact divalent copper and trivalent gold are more stable than the monovalent varieties. The copper family is, therefore, commonly considered to be a transitional family.

Variable Valence Number of Type "e".—There are a number of cases where elements change in valence number as a result of the expansion of the valence shells of their atoms to include more than

eight electrons, making it possible for electrons in unshared pairs each to be shared with a different atom of another element. Outstanding examples of this sort are furnished by the halogen compounds of the non-metals; a few such cases are listed in Table 7.

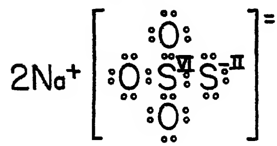
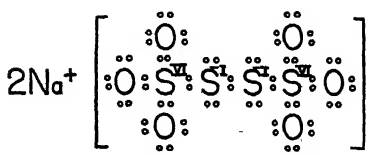
TABLE 7



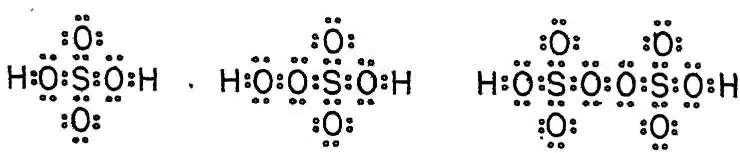
Variable valence of this type is possible only if the valence shell of the element in question can be expanded. Quantum mechanical considerations show that the second or L electron shell has a maximum capacity of eight electrons. Thus it is easy to understand why nitrogen does not form pentahalides as do phosphorus, arsenic, and antimony.

Compounds Containing an Element in Two Different Valence States.—It often happens that the application of the rules for determining valence number to certain compounds of an element lead to fractional, or otherwise anomalous, valence numbers. In a great many of such cases it may be shown that such anomalies result from the existence of the element in the compound in more than one valence state, so that the calculated valence number obtained is an average value for all the atoms of the particular element in the compound. A number of examples of this are given in Table 8. In the third column of this table, Roman numerals are used to indicate valence numbers.

TABLE 8

Empirical Formula	Ave. Val. No. of	Structural or Explanatory Formula
Fe_3O_4	Fe $+2\frac{2}{3}$	$\overset{II}{Fe}O \cdot \overset{III}{Fe_2}O_3$
$InCl_2$	In $+2$	$\overset{I}{In}[\overset{III}{In}Cl_4]$
$Na_2S_2O_3$	S $+2$	
$Na_2S_4O_6$	S $+2\frac{1}{2}$	

In this connection, it should be noted that abnormally high valence numbers have been reported as a result of the failure of the investigator to recognize the existence of a peroxy group in a compound. In terms of accepted definitions, oxygen in a peroxy group (Table 2) has a valence number of —1, not —2. Recognizing this fact, we see e.g. that the valence number of sulfur in the peroxysulfuric acids (improperly called persulfuric acids) is +6, the same as in sulfuric acid and not +7 and +8 as it has sometimes been stated.



Sulfuric   Peroxymonosulfuric   Peroxydisulfuric

Similar statements could be made of all the peroxy acids and salts, many of which are incorrectly named as "per" acids and salts.

Conclusion.—It thus appears that the ability of an element to exhibit more than one valence number can result from a number of different causes, in some cases involving nothing more fundamental than formal definitions. To state simply that an element exhibits variable valence number, without further explanation, adds little to one's knowledge of the element.

Kansas Botanical Notes, 1945, Including Species New to the State*

FRANK C. GATES
Kansas State College, Manhattan.

At Manhattan 1945 started out to be even wetter than 1944 but the dryness of the autumn prevented the year from being a record breaker. The temperature during the early part of the year was distinctly above normal, so much so that by the middle of April the season was about 4.5 weeks ahead of time in spite of there being about three times normal precipitation. After the middle of April so much colder weather obtained that the season lost all of its earliness. On May 12 only a third of the leaves of *Juglans nigra* were out. On May 13, the first leaves of Celtis were frozen completely and a new crop was only a fourth out by the middle of May.

The year 1945 was distinctly a Forsythia year, the first in many years. Freezes early in April took most of the Spirea flowers. This year was a leaf rust year similar to 1938, C. O. Johnston, cereal pathologist, reported, the rust starting six weeks ahead of normal.

An extraordinarily heavy seeding of *Ulmus americana* and *U. pumila* occurred. An unusually fine fasciation occurred in *Dioscorea batatas,* a vine in cultivation in Manhattan. Spread all along the fasciation were full-sized tubers.

Again, with the war not over until after the middle of the year, little attention could be paid to collecting activities. Saline county specimens were received, however, for the state herbarium from John Hancin; Cloud county from S. V. Fraser; Gove county from Clement Weber; Greeley county from Don Cornelius; and Miami county from Bernard Rohrer. The last collection included specimens of *Carex asa-grayi* and of *Dipsacus sylvestris* Huds, new to the state. A Greeley county specimen of *Stipa robusta* collected by Cornelius in July, 1944, was the first definite record of this grass in the state. Reports of it have been made occasionally, but not previously authenticated with specimens.

Gerardia aspera was extraordinarily abundant on K hill near Manhattan this fall. Previously, no more than 3 or 4 specimens had been found in any one year.

Bouteloua curtipendula, the sideoats grama grass was finally

Transactions Kansas Academy of Science, Volume 49, No. 2, 1946.
*Contribution No. 476, Department of Botany and Plant Pathology.

collected in Leavenworth county by G. S. Marshall and sent in to the state herbarium; thus, two plants, this and *Solanum rostratum* are represented in the state herbarium by collections from each of the 105 counties.

Andropogon ischaemum L. has been collected again in the state, this time in Cloud county.

The following, collected during 1945, have not previously been recorded in the Kansas flora:

Carex asa-grayi Bailey. Miami county, by Bernard Rohrer.

Coronilla varia L. Leavenworth county, by George S. Marshall.

Panicum scoparioides Ashe. Cloud county, by S. V. Fraser (determined by Agnes Chase of the National Herbarium).

Rubus kansanus Bailey (Gentes Herbarum 5: 796. 1945) in Cloud county, by S. V. Fraser (determined by L. H. Bailey).

Sisymbrium loeselii L. Cloud county, by S. V. Fraser.

Rogers McVaugh has in WRIGHTIA 1:25. 1945, set up a new species in the old *Specularia perfoliata.* This species, *Triodanis holzingeri,* was collected in the past century in Barber, Ellsworth, Gray, and Seward counties and in 1940 in Cloud county.

The Response of Different Photometers to the Color Produced by Vitamin A and Carotene With Antimony Trichloride*

M. J. CALDWELL, D. B. PARRISH, and W. G. SCHRENK
Kansas Agricultural Experiment Station, Manhattan.

Introduction

Photoelectric colorimeters are commonly employed in the determination of the vitamin A content of biological materials by the Carr-Price antimony trichloride reaction.[4] The procedures have been described in a number of publications.[1,5,7,8] Four different photometers have been used at this experiment station for measuring the blue colors produced when vitamin A and carotene react with antimony trichloride. The response of these instruments shows such wide variation that the results should be of interest to others working in this or related fields.

In the case of a solution of pure vitamin A, the intensity of the blue color produced upon addition of the reagent is directly proportional to the concentration of the vitamin. Since the optical density of the reaction mixture follows the Beer-Lambert absorption law over a considerable range of concentration, measurement of this blue color at the point of maximum absorption (620 mμ) by any photometer would appear to be equally satisfactory, providing account is taken of the loss of color by fading. However, in practice, three factors complicate the measurement of vitamin A. One of these arises if color-inhibiting contaminants are present in the extract containing the vitamin.[10] This difficulty has led Oser et al.,[11] as well as Brew and Scott,[2] to recommend the use of an internal standard in each determination. The remaining complications are functions of the photometer used in the measurement.

Recently it has been shown that the rate of fading of the blue color due to vitamin A is greatly accelerated by the action of light.[3] With instruments employed in this study, fading rates have shown as high as fivefold variation. Photometers utilizing light of low intensity are superior in this respect to those using brilliant illumination, but, in any case, the measurement should be taken at a standard short-time interval after adding the reagent.

The remaining complication relates to the simultaneous production of a blue color by the action of the reagent with non-vitamin A

Transactions Kansas Academy of Science, Volume 49, No. 2, 1946.
*Contribution No. 313, Department of Chemistry.

chromogens such as carotene, xanthophyl, cryptoxanthin, etc. This blue color, which is indistinguishable from that produced by vitamin A as the measurements are taken, has been found to vary among photometers used in this study by as much as 500 per cent in its ratio to the color due to vitamin A itself.

Removal of certain of the interfering pigments from the vitamin A extract prior to the reaction with the Carr-Price reagent has been successful under specific conditions.[1,2] However, in most cases where β-carotene is the predominating contaminant, the usual procedure involves an independent determination of the carotene by the measurement of its yellow color, i. e., absorption at 440 mμ (or 460 mμ). Then by the use of a suitable factor, the equivalent blue color produced by the carotene is calculated and subtracted from the total blue color due to the carotene and vitamin A. This factor represents the ratio of the optical density of the blue color produced by the action of the Carr-Price reagent on a carotene solution measured at 620 mμ to the optical density of the yellow color of an equal concentration of carotene in non-reactive solvent measured at 440 mμ.

For the complete determination three sets of calibration data are prepared: (1) relation of vitamin A concentration to the optical density of the vitamin A-$SbCl_3$ reaction mixture, at 620 mμ; (2) relation of carotene concentration to the optical density of the carotene-$SbCl_3$ reaction mixture, at 620 mμ; (3) relation of carotene concentration in a non-reactive solvent to the optical density at 440 mμ. In preparing these calibration data, wide variations were found to exist in the response characteristics of the different photometers to the same solutions of vitamin A and carotene.

Experimental

The general plan followed in this study was to employ each of four commercial photoelectric photometers to obtain parallel data for a series of known solutions of vitamin A alcohol and β-carotene. From these data calibration curves for each instrument were constructed, the D $^{1\%}_{1cm}$ values calculated, and the correction factors for the presence of carotene determined. Using these data and a known mixture of vitamin A and carotene, experimental values were obtained showing the relative amount of blue color produced by each of the chromogens.

The photometers used represent four distinct types of instruments, and will be labelled A, B, C, and D. The salient characteristics of each are shown in Table I.

TABLE I.—Characteristics of photometers used in the study.

Instrument	Spectral system	Type of photocell	Method of reading	Cell thickness (cm)
A	quartz prism monochromator	cesium oxide	potentiometric, null reading	1.0
B	single diffraction-grating monochromator	barrier layer	galvanometer, direct reading	1.6
C	narrow band filter	barrier layer	galvanometer, direct reading	1.9
D	narrow-band filter	cesium oxide (2 cells)	potentiometric, null reading	1.8

A weighed amount of crystalline vitamin A alcohol[a] was dissolved in U.S.P. chloroform, and dilutions ranging from 1.06 to 7.40 micrograms per ml were prepared. To establish the purity of the vitamin A, spectrophotometric curves in methanol, ether and chloroform were obtained using a Beckman spectrophotometer. The data obtained in ether and methanol solutions are in substantial agreement with those of Morgareidge,[9] and Zscheile and Henry.[14] The absorption maxima in chloroform show the typical shift of wave length produced by a polar solvent. The absorption maximum in chloroform is at 334 mμ; the specific absorption constant is 155 at this wave-length.

β-carotene[b] was dissolved in Skellysolve B, and the concentration and purity were established by use of the Beckman. An aliquot of this solution was evaporated to dryness and taken up in U.S.P. chloroform, from which solution suitable dilutions were made for the Carr-Price and yellow color determinations. For the experimental carotene-vitamin A mixture, a solution was prepared which contained approximately 4 micrograms of vitamin A and 10 micrograms of β-carotene per ml of chloroform. The Carr-Price antimony trichloride reagent was prepared in accordance with the directions given by Koehn and Sherman.[8]

The blue color data (photometric density at 620 mμ) were obtained for the series of vitamin A and carotene solutions using each of the four photometers in turn. The measurements were taken using a wave length setting or filter of maximum transmission of 620 mμ, except in the case of instrument D which was equipped with a 625 mμ filter. Determinations were made using a reaction mixture consisting of 1.0 ml of the solution under test and 9.0 ml of the antimony trichloride reagent. Rapid and complete mixing were assured by use of a specially constructed pipette.[12] Readings were

a. Generously supplied by Distillation Prod. Co.
b. General Biochemicals, Inc.

taken 5-6 seconds after mixing of the reactants, except in the case of photometer A where extrapolation to the 5-second reading was necessary due to instrument design. The carotene-in-chloroform calibration curves were obtained using a wave length setting of 440 mμ or the corresponding filter.

Treatment of Data

With three of the photometers used in this study, the experimental observations were in terms of "transmittance" rather than the more desirable "photometric density" which was given directly by the fourth instrument. To make possible direct comparison among the instruments, the transmittance data are converted to the corresponding photometric density (P.D.) by the relation:

$$\text{P. D.} = 2 - \text{Log T}$$

where "T" is the transmittance in per cent of the light transmitted by the colored solution as compared to that transmitted by an equivalent thickness of the pure solvent.

Of more fundamental significance is the $D^{1\%}_{1cm}$ which is here defined as the photometric density which would be obtained were the absorbing layer one cm in thickness and its concentration one per cent of the substance under investigation. Since light absorption varies with the wave-length of the transmitted light, the $D^{1\%}_{1cm}$ also will vary with the purity of the radiation used in the measurement and is accordingly a function of the photometer. $D^{1\%}_{1cm}$ is calculated from the photometric density by use of the equation:

$$D^{1\%}_{1cm} = \frac{\text{P. D.}}{l\,c}$$

where *l* is the cell thickness in cm, and *c* is the concentration in per cent.

Results and Discussion

In Figure 1 are presented the calibration curves obtained for each of the four photometers using the antimony trichloride reagent with different concentrations of vitamin A and carotene. These data are experimental values for the various instruments, uncompensated for differences in thickness of the absorbing layer. It will be seen that photometer D, while showing the least response to the vitamin A-$SbCl_3$ color, gives the highest response to the similar blue color produced by carotene. This is of major significance in the correction for the presence of carotene in the vitamin A determination, since it results in a large proportion of the total observed blue color being due to the carotene.

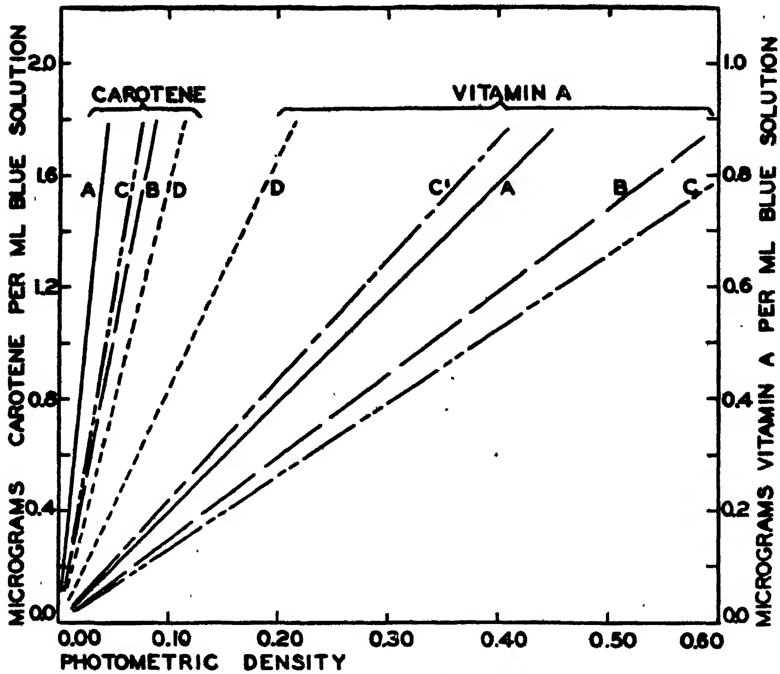


Figure 1.—Calibration curves of four photometers for vitamin A and carotene Carr-Price colors.. These values were obtained using a filter or wave length setting of 620 milli-micron, except in the case of C′ and D where 625 milli-micron filter supplied with photometer D was used.

From the curves in Figure 1, the relative magnitudes of the blue color developed by the two chromogens may be calculated. Let equal concentrations of vitamin A and carotene be assumed in a mixture. Then the ratio of the blue color due to the carotene to the similar blue color due to the vitamin A will vary as follows:

Photometer A, 0.05:1
Photometer B, 0.07:1
Photometer C, 0.05:1
Photometer D, 0.26:1

It thus appears that by using photometer D the correction for carotene is five times as great as the corresponding correction using either photometer A or C.

To confirm these observations the mixture of vitamin A and carotene referred to under "Experimental" was examined using each of the four photometers. The results of this experiment are presented in Table 2. Examination of these data reveals variations in the photometric densities due to the vitamin A of almost 4:1

when the response of instruments C and D are compared. This order reverses when the color due to the carotene component is considered and is approximately 2:3. The percentage of the total blue

TABLE II.—Photometric data obtained using a mixture of vitamin A and carotene.*

Instrument Employed	Total blue color due to vitamin A and carotene (photometric density) at 620 milli-micron†	Yellow color due to carotene. (Photometric density) at 440 milli-micron	Correction factor for carotene (from table III)	Blue color due to carotene (calculated)	Blue color due to vitamin A (by difference)	% of total blue color due to carotene
A	.233	.173	.143	.025	.208	10.7%
B	.323	.238	.189	.045	.278	13.9%
C	.377	.319	.126	.040	.337	10.6%
D	.146†	.276	.208	.057	.089	39.0%

†The 625 milli-micron filter was used with photometer D.
*This solution was made to contain approximately 4 micrograms of vitamin A and 10 micrograms of carotene per ml of chloroform solution.

color of the mixture due to the carotene varies from 10.6 per cent with photometer C to 39.0 per cent with photometer D. If the ratios of the carotene-blue to the vitamin-A-blue obtained with the various photometers are compared, the values range from 0.12 to 0.64, again showing the fivefold variation in response, and confirming the results as calculated from the calibration curves.

In Table 3 are shown the constants, $D^{1\%}_{1cm}$, for vitamin A and carotene determined on each of the photometers.[c] The vitamin A-$SbCl_3$ constants show marked variability among the several photometers, but the carotene-$SbCl_3$ constants show less variation. If photometer D is compared to the others it is noticed that, while the constant obtained with vitamin A is lower, the constant for carotene is larger than that for any other photometer. The carotene-in-

TABLE III.—Photometric constants for vitamin A and carotene obtained using different photometers.

Photometer	Vitamin A $SbCl_3$ D (1%, 1cm)*	Carotene $SbCl_3$ D (1%, 1cm)*	Carotene in Chloroform D (1%, 1cm, 440 milli-micron)	Correction factor†
A	5040	254	1780	0.143
B	4200	300	1590	0.189
C	4030	221	1760	0.126
C′	2440	274	1760	0.156
D	1330	361	1740	0.208

*These values were obtained using a filter or wave length setting of 620 milli-micron, except in the case of C′ and D where the 625 milli-micron filter supplied with photometer D was used.
†See text.

chloroform constants are approximately the same in all cases. The "factor" used to correct for the presence of carotene in vitamin A-carotene mixtures is determined by division of the values in

c. In Table 3 C′ refers to an experiment in which photometer C was modified by substituting the 625 milli-micron filter supplied with photometer D for the original filter.

column 3 by those in column 4 of Table 3. These factors are given in column 5 of Table 3.

Withrow et al.[18] have discussed the design of photoelectric photometers, and have presented data useful in explaining the variations encountered in this study. They pointed out that over 90 per cent of the radiation from an incandescing filament is in the infra-red region of the spectrum. The 625 mμ filter supplied with photometer D, even when used in conjunction with an aqueous infra-red absorbing layer 3 cm in thickness, was found to transmit a high percentage of visible radiation far above the stated transmission maximum of 625 mμ. This observation was made using the visual Bausch and Lomb spectrophotometer. The cesium oxide photocell used in photometer D is particularly sensitive in the red and near infra-red, which radiations are not selectively absorbed by the vitamin A-Carr-Price reaction mixture. Hence, this large amount of non-absorbed radiation penetrates the solution under test and effectively "masks" the absorption in the region near 620 mμ.

That the loss of sensitivity of photometer D in this region of the spectrum is due to both filter and photocell was demonstrated by using the filter from photometer D in photometer C. This replacement decreased the response of photometer C to about 60 per cent of its normal value (Figure 1, Table 2). That the response was not cut to the level of photometer D (about 30 per cent), can be explained by reference to the spectral response curve of the barrier layer type cell as compared to that of the cesium oxide cell.[18] In the case of the barrier-layer photocell, the sensitivity drops rapidly in the region beyond 620 mμ, thereby minimizing the effect of the non-selectively absorbed radiation which is transmitted by the filter. With the cesium oxide cell used in photometer D, the response increases in the region beyond 620 mμ and the effect of this non-absorbed radiation is magnified, resulting in the low sensitivity.

The other variations in photometric data shown in Figure 1 and Tables 2 and 3 can be accounted for, at least in part, by considerations similar to the above. In the case of the carotene-$SbCl_3$ color, a reversal of the order of response among the photometers has been noted. This can be explained by the recently published data of Gibson and Taylor[6] which show that the initially produced blue color of the carotene-$SbCl_3$ mixture, having an absorption maximum at 590 mμ, rapidly gives way to a similar color having an absorption maximum at about 660 mμ. This new absorption band is beyond the range of high sensitivity of the barrier layer type cell, but is in the

region of increased sensitivity of the cesium oxide photocell used in photometer D, which is therefore strongly affected by the longer-wave-length radiations passed by the filter.

The observations recorded in this paper were made with solutions of vitamin A and carotene as the test materials; however, similar results may be expected with any substance having an absorption maximum in the red, or at any other region of the spectrum where the filter and photocell are improperly selected for a particular determination.

This study again emphasizes the necessity for the determination of the photometric constants, correction factors, etc., for the individual photometer to be used in an analytical procedure and of not adopting constants obtained with any other instrument.

Summary

1. The response of four commercial photometers to the Carr-Price reaction mixtures encountered in the determination of Vitamin A has been shown to vary markedly.
2. These variations have been shown to be due to the different photocell and optical systems incorporated in the construction of the photometers.
3. The necessity for the calibration of each photometer for the determination of vitamin A, as well as the correction factor for the presence of carotenoids, has been demonstrated.

Literature Cited

(1) Boyer, P. D., Phillips, P. H., and Smith, J. K., J. Biol. Chem., 152, 445, (1944).
(2) Brew, W., and Scott, M. B., Ind. Eng. Chem., Anal. Ed., 18, 46, (1946).
(3) Caldwell, M. J., and Parrish, D. B., J. Biol. Chem., 158, 181 (1945).
(4) Carr, F. H., and Price, E. A., Biochem. J., 20, 497 (1926).
(5) Dann, W. J., and Evelyn, K. A., Biochem. J., 32, 1008 (1938).
(6) Gibson, G. P., and Taylor, R. J., Analyst, 70, 449 (1945).
(7) Kimble, M. S., J. Lab. and Clin. Med., 24, 1055 (1939).
(8) Koehn, C. J., and Sherman, W. C., J. Biol. Chem., 132, 527 (1940).
(9) Morgareidge, K., Ind. Eng. Chem., Anal. Ed., 14, 700, (1942).
(10) Norris, E. R., and Church, A. E., J. Biol. Chem., 85, 477 (1929-30).
(11) Oser, B. L., Melnick, D., and Pader, M., Ind. Eng. Chem., Anal. Ed., 15, 724, (1943).
(12) Parrish, D. B., and Caldwell, M. J., J. Lab. and Clin. Med., 29, 992, (1944).
(13) Withrow, R. B., Shrewsbury, C. L., and Kraybill, H. R., Ind. Eng. Chem., Anal. Ed., 8, 214, (1936).
(14) Zscheile, F. P., and Henry, R. L., Ind. Eng. Chem., Anal. Ed., 14, 422, (1942).

A Revamped Laboratory Course in Electronics Based Upon Wartime Practices

HARVEY A. ZINSZER
Fort Hays Kansas State College, Hays.

In the Radar Program at Harvard University during the recent world war it was apparent, both at the time of the entrance examination for admission to the course and throughout the course itself, that officers who had had previous training in electronics made a showing superior to those who were not similarly prepared.

This information and the demands for experienced electronicians in navigation, airborne and marine, in the weather service, in telephony, in television, and pre-eminently in radio, make it desirable that departments of physics include in their undergraduate curriculum a substantial course in electronics along with the other traditional courses in that field.

Assuming an adequate preparation in mathematics and in the elements of electricity and magnetism, it would appear that a course in electronics should include studies in the following subjects: alternating currents, circuit elements, test instruments, networks, vacuum tubes, rectifiers and filters, amplifiers, circuit matching, detection, modulation, receivers, cathode-ray oscilloscopes, transients, signal distortion, transmission lines, transmitters, antennas, wave propagation, ultra-high frequency circuits, and ultra-high frequency generators. While not all of these subjects may be found between the covers of a single textbook, there is now available a wealth of material in various textbooks which might be assembled into a unified course and which with adequate facilities would require two semesters for its completion.

Such a course covers considerable territory and when given during the war, principally to engineering and physical science students, was a fulltime job for all of three months. So it depends upon the thoroughness with which the course is to be conducted and upon the apparatus available, whether the course be allotted six hours of credit over two semesters or five hours of credit over one semester. In the latter event, the various subjects embodied in the course would of necessity be only lightly touched upon. This situation calls for a concise textbook in this field, the same to have a liberal supply of problems and worked-out examples.

Transactions Kansas Academy of Science, Volume 49, No. 2, 1946.

The laboratory credit should by all means cover two semester hours whether given in a single semester or in two semesters. It should consist of two phases of work, namely, a constructional phase and a formal phase, each to run concurrently with the other. Furthermore, it would appear rather desirable to carry on the constructional phase of the laboratory work in a workshop separate from the formal laboratory.

A list of experiments which one might suggest as a basis for such a laboratory course follows shortly. The references for these experiments may be found in various radio and electronics journals such as Q.S.T., the I.R.E. Proceedings, Electronics, Communication, FM and Television, Frequency Modulation, as well as in the A.R.R.L. Handbook and in Terman's Radio Engineering Handbook, not to mention a substantial list of textbooks.

FORMAL LABORATORY

1. Measurement of R, L, and C.
2. Test Instruments and their Scope.
3. Q-meter and Properties of a Coil.
4. Tube Testing and Dissection of Receiver Tubes.
5. Electrostatic and Magnetic Deflection of the Cathode Ray.
6. Cathode Ray Oscilloscope Controls and the Electronic Switch.
7. Static Characteristics of Vacuum Tubes.
8. Variational Characteristics of Vacuum Tubes.
9. Equivalent Plate Circuit Theorem.
10. Voltage Regulated Power Supply.
11. Resistance-Coupled Amplifier.
12. The Video Amplifier.
13. Feedback Amplifier and Cathode Degeneration.
14. The Cathode Follower.
15. Oscillators and Ultra-High Frequency Generators.
16. Trigger Circuits with Gas Tubes and with Hard Tubes.
17. Recurrent-Pulse Shaping Circuits.
18. Limiter and Discriminator.

CONSTRUCTION LABORATORY

1. Shop Practice—Use of Hand Tools in Constructing a Chassis.
2. Power Supply and Filter Construction.
3. Voltage Doubler Construction and Study of Load Characteristics.

4. Familiarization of Color Code and Circuit Tracing in a Superhetrodyne.
5. Circuit Testing in a Superheterodyne with a Volt-ohmmeter.
6. Signal Tracing in a Superheterodyne with a Chanalyst.

7-12. Wiring and Aligning a Superheterodyne.

13. Transmitter Servicing.
14. Non-Resonant Lines and Matching Sections.
15. Resonant Lines.
16. Antenna Patterns.
17. Wave Guides.
18. Ionosphere Reflections.

Nesting of the Yellow-headed Blackbird in Douglas County, Kansas

by
HENRY W. SETZER AND R. L. MONTELL
University of Kansas, Lawrence

A breeding colony of Yellow-headed Blackbirds (*Xanthocephalus xanthocephalus* Bonaparte was observed in Douglas County, Kansas, in the spring of 1945. Because of the paucity of information on the breeding status of this species in Kansas it seems desirable to present our data.

Snow (1872) regarded this form as abundant. Goss (1886 and 1891) recorded this species as nesting in "quite a colony" along Crooked Creek, Meade County, Kansas. He reported it as occurring also in other parts of the state but did not give exact localities. Linsdale and Hall (1927) noted flocks in Douglas County on April 24 and 25, 1920, and on April 25, 1922, but did not list them as breeders. Long (1940) listed this species as a rare summer resident in Kansas, and Hibbard and Rinker (1943) mentioned it as a breeding bird in Meade County. Harris (1919) listed colonies breeding at Armour and Bean lakes, Platte County, Missouri.

The collections of the Museum of Natural History of the University of Kansas contain fifteen conventional study skins and two mounted specimens of the Yellow-headed Blackbird from Kansas. These specimens are from Norton, Wallace, Douglas, Pratt, Morton, Meade and Barber Counties. Of these counties, only Douglas, Pratt, Morton and Meade are represented by birds taken in the breeding season; the other records are of birds taken in periods of migration. As may be seen from the above, with the exception of those in Douglas County, the breeding birds were known previously only from the western counties.

On June 4, 1945, Mr. Klaus Abegg and one of us (Montell) observed approximately fifteen Yellow-headed Blackbirds two and one-half miles northeast of Lawrence, Douglas County, Kansas. A pair of these was collected. On June 5, the authors again visited the colony and took another pair of adult birds, when fresh eggs, newly hatched young and young almost ready to leave the nest were found. On this date in the restricted area examined by us (approximately 5000 square feet) twelve nests were counted. One of us (Montell) visited the nesting area on June 12, 19 and 26, and

counted a total of thirty-eight nests, which implies that there were approximately eighty birds nesting in the area. This nesting area is about one-fourth of a mile long and twenty-five feet wide and extends along the south side of a pond which was formed from an old ox-bow lake of the Kansas River. As is characteristic of this type of pond, the edges were bordered by cat-tails, rushes and willows. All of the nests observed in this area, however, were constructed only in cat-tails over open water. Although this pond is one of a series it was the only place the birds were frequenting.

Literature Cited

Goss, N. S.—Birds of Kansas. Kans. Publishing House, pp. 76, 1886.

——— History of the Birds of Kansas. Geo. W. Crane and Co., Topeka, Kansas, pp. 692. 1891.

Harris, Harry—Birds of the Kansas City Region. Trans. Acad. Sci. of St. Louis, Missouri, pp. 213-371. 1919.

Hibbard, C. W. and G. C. Rinker—A New Meadow Mouse (*Microtus ochrogaster taylori*) from Meade County, Kansas. Univ. Kans. Sci. Bull., vol. 29, pt. 2, no. 4, pp. 255-268. October 15, 1943.

Linsdale, J. M. and E. R. Hall—Notes on the Birds of Douglas County, Kansas. Wilson Bull., vol. 39, pp. 91-105. June, 1927.

Long, W. S.—Check-list of Kansas Birds. Trans. Kans. Acad. Sci., vol. 43, pp. 433-456. 1940.

Snow, F. H.—Catalogue of the Birds of Kansas. Trans. Kans. Acad. Sci., vol. 1, pp. 21-29. 1872.

Possible Use of Entry Occupational Classification, Dictionary of Occupational Titles, Part IV, by High School Counselors

EDWARD W. GELDREICH
Kansas State Teachers College, Emporia.

The ultimate goal of a high-school vocational guidance program is the satisfying vocational placement or direction of each pupil, or, at least, the assisting of each pupil in the correct choice, preparation, and/or training for some satisfying vocational course of action. The big problem is the realization of a satisfying course of action. In assisting the pupil, in addition to obtaining the best and most complete information about the pupil, one needs to know the world of work opportunities and the possibilities of satisfying vocational expression—one must have occupational information.

Those high-school teachers and administrators who have attempted to set up and operate a guidance program have found their greatest difficulty in acquiring the necessary occupational information. These same teachers and administrators may have successfully established an excellent testing program and acquired a wealth of accumulated information about the pupil, but all this is just so much static information unless it is matched with the objectives of the pupil and the requirements of vocational pursuits. Our counseling program fails if we fail to note the relationship between what is "given" in the basic information about the student, the pupil's self-knowledge of opportunities, and the demands of possible courses of activities which the pupil may choose to realize expression. Many teachers and administrators reach the "so what" and "what next" stages when they have acquired a certain amount of scholastic, mental ability, interest, and personality data about the student. The guidance from there on sometimes takes on the haphazardness of shot gun proposals through a course in "Occupations." At this point the conscientious (though misguided) teacher-counselor or principal prays for a "test" which will tell his students what each can do. It goes without saying that this directive type of counsel violates the fundamental purpose of guidance—that of maintaining the sense of self-decision in choices of action.

The purpose of this paper is to describe the "Entry Occupational Classification," volume IV of the D.O.T.[7], as a useful source

of information which may be used with benefit to both the high-school counselor and counselee and to indicate how the volume may be used to nibble at the "Gordian knot" of guidance.[2] The Entry Occupational Classification was designed for use by the United States Employment Service in the classification of new worker applicants. The volume was designed to relate a number of classification factors such as personal traits, leisure-time activities, casual work experience, and training courses to entry jobs, that is, jobs which the new worker may enter without previous experience. Jobs not requiring previous experience are jobs which are simple in nature, jobs for which there are on-the-job training facilities, and/or jobs for which previous education or vocational training replaces an experience requirement.[5]

The value of the E.O.C. to the Employment Service may be appreciated when it is realized that about half of all the jobs of the world do not require previous experience. Thus with the aid of the E.O.C., new workers, and old workers requesting a change in jobs, may be classified according to the factors listed in the volume. The E.O.C. may be most valuable in the counseling of high-school pupils, for the counselor must have on hand not only general occupational information but a clearly structured concept of the types of jobs which beginners can enter.

Any factor of behavior or item of information about a pupil that has any occupational significance should be ascertained by the counselor. The E.O.C. aids the counselor in systematically pointing out the occupational significance of school courses, casual or partially qualifying work experience, interests, aptitudes, hobbies, and other leisure-time activities. The counselor must recognize the need of care in using the E.O.C. and in taking advantage of the occupational reference of the factors; for no one factor must be regarded as completely significant of vocational placement and success; even the listing of several significant factors with respect to a pupil must be judged in terms of their "degree" of significance. In addition, the counselor must consider the pupil's physical characteristics, willingness to work in a particular work environment, extent or quality of training, and similar factors if any immediate or future placement upon a job is to be made.

Without going into detail concerning the entry classification structure, we note that the E.O.C. has six fields of work, each represented by a 2-digit code number, the X meaning entry. There

are twenty-two 3-digit, sixty-eight 4-digit, 136 5-digit, and two hundred 6-digit breakdowns. With this simple and inadequate statement of the classification structure of entry jobs we now can describe the factors delineated in the E.O.C. The two- and three-digit classification of entry jobs is shown in Table I.

TABLE I—Summary of Major Occupational Groups and Basic Two- and Three-Digit Classifications[1]

0-X	Professional, Technical, and Managerial Work	
	0-X1	Artistic Work
	0-X2	Musical Work
	0-X3	Literary Work
	0-X4	Entertainment Work
	0-X6	Public Service Work
	0-X7	Technical Work
	0-X8	Managerial Work
1-X	Clerical and Sales Work	
	1-X1	Computing Work
	1-X2	Recording Work
	1-X4	General Clerical Work
	1-X5	Public Contact Work
2-X	Service Work	
	2-X1	Cooking
	2-X3	Child Care
	2-X5	Personal Service Work
3-X	Agricultural, Marine, and Forestry Work	
	3-X1	Farming
	3-X8	Marine Work
	3-X9	Forestry Work
4-X	Mechanical Work	
	4-X2	Machine Trades
	4-X6	Crafts
6-X	Manual Work	
	6-X2	Observational Work
	6-X4	Manipulative Work
	6-X6	Elemental Work

[1]U. S. War Manpower Commission, Bureau of Manpower Utilization, Division of Occupational Analysis, *Dictionary of Occupational Titles,* Part IV, Entry Occupational Classification, p. 2. rev. ed. Washington, D. C., U. S. Government Printing Office, 1944.

The personal traits having occupational significance are patterned in relation to the twenty-two 3-digit classification of occupations. The use of this information would be obvious to a counselor, particularly the beautiful systematic structure of the relationships.

Personal traits as listed here include vocational interests, aptitudes, personality traits, and worker characteristics other than vocational training, work experience, and leisure time activities. Such traits are important as classification factors only to the extent that they reflect habits, abilities, and attitudes that go to make up occupational patterns associated with successful performance in specific types of work. It is the cumulative effects of traits that produce occupationally significant factors. A person who is neat, clean, poised, confident, interested in people, and possessed of a manner inviting trust presents a pattern of personal traits associated with success in "sales" work. Considered alone, such traits may be of questionable value for classification. Combined with training, and other classification factors, such as leisure time activities and casual work experience, personal traits are significant in indicating what occupation he is equipped to enter.

Possession of a given personal trait may be advantageous in many types but not sufficiently important to be used as a basis for classification or as an indicator of occupational fitness. The same trait, in other cases, clearly indi-

cates information important for classification, or occupational fitness. Personal neatness, for example, is a valuable consideration in almost any type of vocational activity, but is practically demanded in nursing and medical work, selling, and adult care. (7:159)

The pattern of personal traits associated with public contact work is given as an example:

1-X5 Public Contact Work

Persons with an occupationally significant combination of such traits as:

Attractive appearance
Pleasant speaking voice
Language facility and fluency
Sensitivity to the attitudes and reactions of others
Tact, poise, and persuasiveness
Ability to maintain equanimity in the face of indifference, resistance, or affront
Drive and initiative
Mental alertness; patience and attentiveness
Mental ability to develop techniques of approach and conversation in order to secure desired responses
Liking for people and for association with them

Such traits may be estimated from observation of the individual, interest inventories, active participation and leadership in group activities, or success in sales activities such as demonstrating, soliciting donations, or selling magazines, tickets, or articles of merchandise. (7:162)

Of importance to the counselor are the methods suggested for estimating the personal traits listed.

The clues of hobbies and leisure-time activities are regarded by the counselor as having significance for entry occupational classification and in the counseling for long-term programs of a vocational course of action. Properly used, the E.O.C. is most valuable. Of course, it is assumed that such activities are indicative of certain interests which may develop significant work habits and skills. Many of the occupational relationships to the hobbies, etc. listed in the E.O.C. are obvious, but it is handy to the counselor to have them so nicely listed and structured. It is important to note that the listing in the E.O.C. takes into consideration the differing degrees of proficiency with which the leisure-time activities are pursued.

For example: "Model airplanes" is listed with the codes 6-X4—4-X2.103; 4-X2.104; 4-X6.3—0-X7.7; 0-X7.4.

The pupil who has built model airplanes may have merely cut out and assembled stamped pieces which suggests 6-X4, manipulative work; or perhaps 6-X4.2, structural work; or 6-X4.3, bench work. He may, however, have developed his hobby sufficiently by building gas engine models or scale models to suggest 4-X2.103, combustion engine repairing; 4-X2.104, aircraft equipment repairing; or 4-X6.3, bench crafts, etc. Intensive study of aerodynamics,

aircraft design, or aircraft plans would imply characteristics which might suggest 0-X7.7, drafting; or 0-X7.72, structural drafting; or even 0-X7.4, engineering; 0-X7.42, structural engineering; 0-X7.44, mechanical engineering; or 0-X7.49, technical control work.

Casual work experience is likewise an important factor in counseling high-school pupils. In some counseling situations the casual work experience may be in the same direction as a pupil's interests and abilities, and the pupil may desire to pursue the same course of action. In other instances the experience may be listed as merely exploratory, or as evidence of dissatisfaction with a certain type of work, or as a simple record of having held down a job. Some experts in guidance regard work experience as *par excellance* in determining a choice of an occupation. Others ask how part-time work as a newsboy or grocery clerk can help a pupil decide on a full-time job. The high-school counselor can turn the trick by breaking the casual work experience or part-time work into its performance parts —a job analysis. He may then relate the job to its job family.(1) In terms of job-family analysis and the attitudes and skills of the pupil with respect to the different performances on the part-time job, the counselor can go a long way in assisting the pupil in making a choice.(6) If an evaluation can be made of significant casual work experience—and that is the hitch—we have then one of the best checks on the operation of many occupationally significant factors and one of the best determiners of a choice for some future vocation.

The E.O.C. lists and relates the following casual work experiences to entry jobs: basic military training, bus boy or girl, delivery boy, farm hand, gas station worker, house-to-house canvassing, housework—male and female, newsboy work, soda dispensing, store work—grocery or variety, store work—specialty shop or department store, telegraph messenger work, truck helper, and ushering. Some of the relationships of some of these experiences to specific jobs are obvious, others not so obvious. The E.O.C. relates these experiences to 143 occupational classifications.

Previous training in any vocational direction is given much weight in counseling with high-school pupils. Since most high-school graduates receive no further training, the training at that level is most significant in vocational counseling. The E.O.C. lists about 1,500 different kinds of military and civilian specialized training related to appropriate entry placement. The civilian training courses listed are the usual courses offered at the secondary and

junior-college level. Of course, variations in local training conditions may also suggest different entry relationships. The codes assigned to the courses of training are merely suggestive. Some of the assigned classification is quite obvious, some very general—2 and 3-digit classifications, and some quite specific. For example:

Shop mathematics—4-X (mechanical work).
Plane geometry— 0-X7 (technical work).
4-X (mechanical work).
Salesmanship— 1-X5.5 (selling).
0-X7.1 (accounting, legal work, purchase and sales work, business relations work).
Sheet metal work—4-X6.213 (light metal structural work).
4-X6.313 (sheet metal shop work).

The above description of the Entry Occupational Classification is sufficient for the purposes of this paper. The best description may be obtained by an investment of 35 cents for the volume.

I have found the volume of interest to college students particularly after they have written a "vocational autobiography" such as the one suggested by Milton Hahn.[8] This autobiography brings into relief courses of study, liked and disliked; hobbies and other leisure-time activities; traits; aptitudes; etc. The E.O.C. is then used to see the reference to possible entry jobs. The student is given an opportunity to size up the fields of work, at least in terms of job titles. The Dictionary of Occupational Titles, Part I, then becomes useful, for the student desires very often a definition of the titles he reads in E.O.C. Here we give the student counselee the same opportunity the counselor has in studying the counselee's vocational problem. Together they may bring a satisfactory solution to the counselee's problem. I think it is a good recommendation never to "assist" in the guidance process beyond a 3-digit classification using only the classification factors of the E.O.C., but aided by strong supporting evidence of strong specific and verified interests, motivation, and specific vocational training courses, a 5- or 6-digit classification may be made and guidance provided accordingly.

The volume should have obvious value in the counseling of high-school drop-outs who are immediately entering the labor market and who should be placed to their greatest advantage. Every dimension indicative of possible success in a given vocational direction or course of action should be used by the counselor and coun-

selee. The E.O.C. aids the counselor in relating many of these dimensions of behavior to specific occupations.

Where guidance programs permit the scheduling of work experience as a part of the plan of providing vocational exploration, again we can see the value of the E.O.C. Jobs can be picked in terms of the exploratory needs of the pupil and in terms of the partial fulfillment of the classification factors required for the jobs.

Again, the use of the E.O.C. can be appreciated in the case of those pupils who have already made a vocational choice of action and are planning, preparing, and training for that action. The future use of casual work experience related to success in the long-term planned vocation can be neatly planned from the E.O.C.

Of course, the E.O.C. can be used generally to inform the pupil of the needed background for a given vocation. The volume thus is a source book of useful occupational information.

Bibliography

(1) Christensen, Thomas F. "Work Experience as Try-outs," *Occupations,* XXIV (April, 1946), 401-405.

(2) Fredenburgh, F. A. "The Gordian Knot of Vocational Guidance," *Journal of Applied Psychology,* XXVIII (February, 1944), 63-66.

(3) Hahn, Milton E. and Brayfield, A. H. *Job Exploration Workbook for Occupational Laboratory Students.* Chicago: Science Research Associates, 1945. Pp. 95.

(4) Nichols, William O. "A New Tool for Counseling," *Occupations,* XXIII (May, 1945), 447-450.

(5) Shartle, Carroll L. *Occupational Information, Its Development and Application.* N. Y.: Prentice-Hall, Inc., 1946. Pp. 339.

(6) Toop, H. A. "Some Concepts of Job Families and Their Importance in Placement," *Education and Psychological Measurement,* V (December, 1945), 195-216.

(7) U. S. War Manpower Commission, Bureau of Manpower Utilization, Division of Occupational Analysis. *Dictionary of Occupational Titles, Part IV: Entry Occupational Classification,* rev. ed. Washington: Government Printing Office, 1944. Pp. 242.

(8) Ward, Raymond S. "How to Use Part IV of the Dictionary," *Occupations,* XXII (October, 1943), 39-41.

Milkweed Floss Collection in Kansas

C. F. GLADFELTER
Kansas State Teachers College, Emporia.

In the spring of 1944 the government saw the necessity of setting up a milkweed floss collecting campaign to provide a substitute for kapok, which had been obtained from Java. Dr. Boris Berkman, Russian born Chicago physician, had already done considerable research on the milkweed. He found that each fiber was a single air-tight cell, coated with wax, making it impervious to water. Twenty-eight ounces of this white fluffy fiber would hold a man up one hundred forty hours.

The United States Department of Agriculture and the War Food Administration were charged with the responsibility of getting this floss for the Navy. They turned the processing over to the War Hemp Industries, Incorporated, of Petoskey, Michigan, which was already under government contract.

The program was set up in thirty-three states. The collection in Kansas included fifty eastern counties. The work started July 1, and ended January 15, 1945.

We collected five species: *Asclepiodora viridis* (Walt.) A. Gray, commonly called green or prairie milkweed, *Asclepias sullivanti* Engelm., commonly called clasping milkweed, *A. syriaca* L., the common milkweed, *A. syriaca* var. *kansana* (Vail), the Kansas milkweed, and *Gonolobus laevis* Michx., commonly called sandvine or climbing milkweed.

Since this was the first large-scale milkweed collection work in Kansas, we learned a lot as to the prevalence of the different species in various counties and the dates of their maturity. In the southeast we found an abundance of Asclepiodora or prairie milkweed. The first two weeks of July were spent in getting these southeastern counties organized. The organization consisted of the county superintendent, county agent, home demonstration agent and club agent, Boy Scouts, Girl Scouts, Soil Conservation Service, the Farm Security Administration, Red Cross, Future Farmers of America and county weed supervisors, each promoting the program in their county. Sacks and money were furnished them and they paid the pickers twenty cents a sack, (about 5 pounds dry weight). By the time the

southeastern counties were organized the prairie milkweed had matured and most of the floss had blown away. As a result we collected only four hundred sacks whereas we should have collected 20,000 to 25,000.

Around one hundred sacks of *Asclepias sullivanti,* the clasping milkweed, was collected in Chase, Lyon, Coffee, Osage and Anderson counties. *Asclepia syriaca* and *A. syriaca* var. *kansana,* the common and the Kansas milkweeds, were found in abundance in northeast Kansas, i.e., from Lyon county to Washington county on the north and from Lyon county to Miami county on the east. Thickest stands were found in Jackson and Jefferson counties; Jefferson county collected 1,575 sacks; Jackson county, 1,515 sacks; Brown county was third with 1,143 sacks; Nemaha county was fourth with 886 sacks, and Johnson county was fifth with 850 sacks.

Gonolobus laevis, the climbing milkweed, was found on all the river bottom lands in eastern Kansas. Thickest stands were found on the Kansas river from Topeka to Kansas City and on the Missouri river from St. Joseph to Kansas City. For some reason this did not set pods very heavily in certain areas. In places it was heavy; one plant was found with thirty-three pods. We secured around five hundred sacks of this species.

Some of the communities that ranked high in the number of sacks gathered were: McLouth, 368 sacks; Willis High School, 350; Tonganoxie, Future Farmers of America, 276; Baileyville Catholic School, 150. Henry Haub of Holton, Kansas, 70 years old, picked 105 sacks and a 4-H Club girl in Atchison county picked 32 sacks. Kansas, with 12,000 sacks collected, ranked twentieth among the thirty-three states carrying the program. Michigan was first with 540,000 sacks.

Kansas boys and girls collected enough floss to make 6,000 life preservers, thereby doing their bit toward the winning of the war.

Minutes and Reports of the 78th Annual Meeting, Kansas Academy of Science, Emporia, Kansas, April 11-13, 1946

The 78th annual meeting of the Kansas Academy of Science was held at Kansas State Teachers College, Emporia, Kansas, April 11-13, 1946. The Executive Council consisting of J. W. Breukelman, C. W. Hibbard, F. W. Albertson, D. J. Ameel, Robert Taft, W. J. Baumgartner, J. C. Peterson, L. D. Bushnell, and Paul Murphy met at 4:00 p m., Thursday, April 11, and transacted the following business:

1. It was agreed to recommend that the 1947 meeting be held at the University of Kansas, Lawrence Kansas, and to recommend that the invitation of the Kansas State Teachers College to meet with them at Pittsburg in 1948 be accepted.

2. It was recommended that amendments 9 and 10 to the constitution voted on in 1943 but overlooked in 1945 when the revised constitution was published be included in the present constitution as sections 10 and 11.

3. It was recommended that the secretary and managing editor negotiate with the co-operating libraries for the renewal of the five year contract for the purchase of volumes of the *Transactions.*

4. It was voted to authorize donations of surplus volumes of the *Transactions* to libraries in foreign countries destroyed by enemy action. The volumes are to be seleced at the discretion of the secretary, managing editor and librarian and the transportation is to be borne by the recipient.

5. It was proposed that in section 8 of the constitution the words "Kansas Journal of Science" be substituted for *Transactions of the Kansas Academy of Science.*

6. It was recommended that accumulated interest from the funds of the Academy, other than that from the Reagan fund, be placed in our general fund for the 1946-1947 Academy year.

7. It was agreed that the matter of reinvestment of surplus funds of the Academy be left up to the finance committee.

At the general business meeting at 10:10 a. m. on Friday, April 12, the Academy transacted the following business:

1. It was voted upon recommendation of the council to hold the 1947 meeting at the University of Kansas, Lawrence, Kansas, and the 1948 meeting at Pittsburg.

2. It was recommended that amendments 9 and 10 to the constitution voted on in 1943 be included in the present constitution as sections 10 and 11. These sections are as follows:

Section 10. The Academy shall have a librarian to be elected yearly at the annual meeting.

Section 11. The chairman of the Junior Academy of Science shall be elected for a period of three years. He shall be a member of the Executive Council.

3. It was voted that the secretary and managing editor negotiate with the co-operating libraries for the renewal of the five year contract for the purchase of volumes of the *Transactions.*

4. It was voted to donate surplus volumes of the *Transactions* to libraries in foreign countries destroyed by enemy action. The volumes are to be selected at the discretion of the secretary, managing editor and librarian and the transportation is to be assumed by the recipient.

5. It was voted that the matter of reinvestment of surplus funds of the Academy be left up to the finance committee.

6. It was voted that accumulated interest from the funds of the Academy, other than that from the Reagan fund, be placed in our general fund for the 1946-1947 Academy year.

7. Dr. John C. Frazier, Academy delegate at the A.A.A.S. Academy Conference at St. Louis gave a report on the meeting.

8. The report of the secretary was presented and accepted.

9. The report of the treasurer was presented and accepted.

At the general business meeting at 8:30 a. m. on Saturday, April 13, the Academy transacted the following business:

1. The report of the managing editor was presented and accepted.

2. Since there were no applications for Academy awards, the committee was empowered to act on its own discretion in granting the awards during the year.

3. The report of the necrology committee was made and accepted.

4. The report of the auditing committee was made and accepted.

5. The committee on conservation and ecology made the following recommendations:

a. To seek the cooperation of the grassland research group with the committee on conservation and ecology.

b. That consideration of "Rock City" and a section of the Flint Hills as state parks be urged upon the state legislator.

c. That a survey be made of the areas to be inundated in construction of dams.

6. The report of the resolutions committee was presented and accepted. The report read as follows:

Be it resolved:

(1) That the Kansas Academy of Science thank the local committee and the administration of the Kansas State Teachers College of Emporia for their careful planning and well organized arrangements for the various meetings of the Academy.

(2) That the success of the meeting is the result of careful planning on the part of the Executive Committee.

(3) That the Academy is happy to resume its regular three day meetings after several years of curtailed meetings due to the conflict of World War II.

(4) That the Academy welcomes back into its active membership those members of the Academy who have served their country in the armed forces.

(5) That the Academy is indebted to the Kansas State Teachers College of Emporia for sponsoring the lecture given by Mr. E. Finley Carter.

(6) That the Kansas Academy of Science expresses its appreciation of Mr. E. Finley Carter, vice-president of the Sylvania Electrical Products Co., Inc., and to Dr. S. W. Cram through whose solicitation Mr. Carter's services were procured for Mr. Carter's thought inspiring lecture on "The Scientist's Increasing Social Responsibility."

(7) That the Academy be grateful to Mr. C. F. Gladfelter for arranging the annual dinner for members and their visiting guests.

(8) That the visiting women appreciate the reception and tea given by the local women on Friday afternoon.

(9) That the absence of Dr. L. C. Wooster, the oldest member of our Academy, who in the past was prominent not only through his contributions to the Academy, but also because of his regular attendance, was noted and that his presence was greatly missed.

7. The Academy voted to continue men in the armed forces on the membership list regardless of whether they had paid the current dues.

8. It was voted that amendments 9 and 10 to the constitution voted on in 1943 be included in the present constitution as sections 10 and 11.

9. It was voted that action on the change of name of the *Transactions* be postponed and that a committee of three be appointed by the president to study this proposal and to report at the next meeting.

10. The nominating committee reported as follows: President, Dr. Claude W. Hibbard; President-elect, Dr. J. C. Peterson; Vice-president, Dr. F. W. Albertson; Secretary, Dr. S. M. Pady; Treasurer, Prof. S. V. Dalton; additional executive council members, Dr. J. W. Breukelman, Dr. Paul G. Murphy; Dr. P. S. Albright; Ralph Rogers (chairman of Junior Academy); Managing Editor, Dr. W.

J. Baumgartner (3 years); Associate Editor, Dr. Paul Murphy (3 years); Academy Librarian, Dr. D. J. Ameel. The report of the nominating committee was adopted and the above officers duly elected.

The executive council for 1947 convened at noon April 13, at which time the following business was transacted:

1. The receipt of a letter from Mrs. Reagan was acknowledged.

2. The following amounts were made available to Academy committees: $100 for the committee on conservation and ecology, $50 to the committee on state aid, $100 to the Junior Aacademy and $50 to the committee on educational trends in science teaching.

3. The president was authorized to establish new sections for the next meeting if the need should arise.

DONALD J. AMEEL,
Secretary

Transactions
Kansas Academy of Science

Volume 49, No. 3 — December, 1946

Kansas and the Nation's Salt

ROBERT TAFT
Professor of Chemistry, University of Kansas, Lawrence.

"Do you know why you northerners whipped us southerners?" asked an ex-confederate officer of a northern audience after the close of the Civil War. "Because you had salt," he told his audience. This surprising statement is made on the first page of Professor Ella Lonn's book, Salt As a Factor in the Confederacy, *but it is only one illustration of the important part that salt has played in world history. If salt is a basic raw material in the chemical industry of a nation, its use to the individuals of a nation is no less important. One need but recall that amusing description of this substance given by the small boy as "Something that don't taste good when it ain't there" to illustrate the second point.*

The article which follows reviews, among other factors, the important part Kansas has played for the past sixty years in the production of this basic and fundamental national and individual need.—The Editor.

World Production of Salt

Salt is produced by evaporating sea water; by harvesting salt in arid countries from dried-up lakes and seas; by sinking a shaft beneath the surface of the earth to beds of solid, or rock, salt, and mining this mineral in much the same way that coal is mined; and by recovering or pumping salt brine from wells. Brines may occur naturally in certain localities and are encountered by drilling; or surface water may be forced down a well until it encounters rock salt which dissolves in water producing an artificial brine. The artificial brine may then be pumped to the surface and evaporated to recover the salt.

Although all of these methods are employed, the production of rock salt and of natural and artificial brines constitute the most important methods in the world's output of some 31,000,000 short tons of salt reported in 1938, the last year that data on anything approaching a complete basis are available for world production.[1]

[1]Florence E. Harris and E. M. Tucker, *Salt*, Washington, 1946 (preprint from *Minerals Yearbook 1945*), pp. 14-15. These authors estimate that world production of salt was about 36,000,000 short tons in 1944.

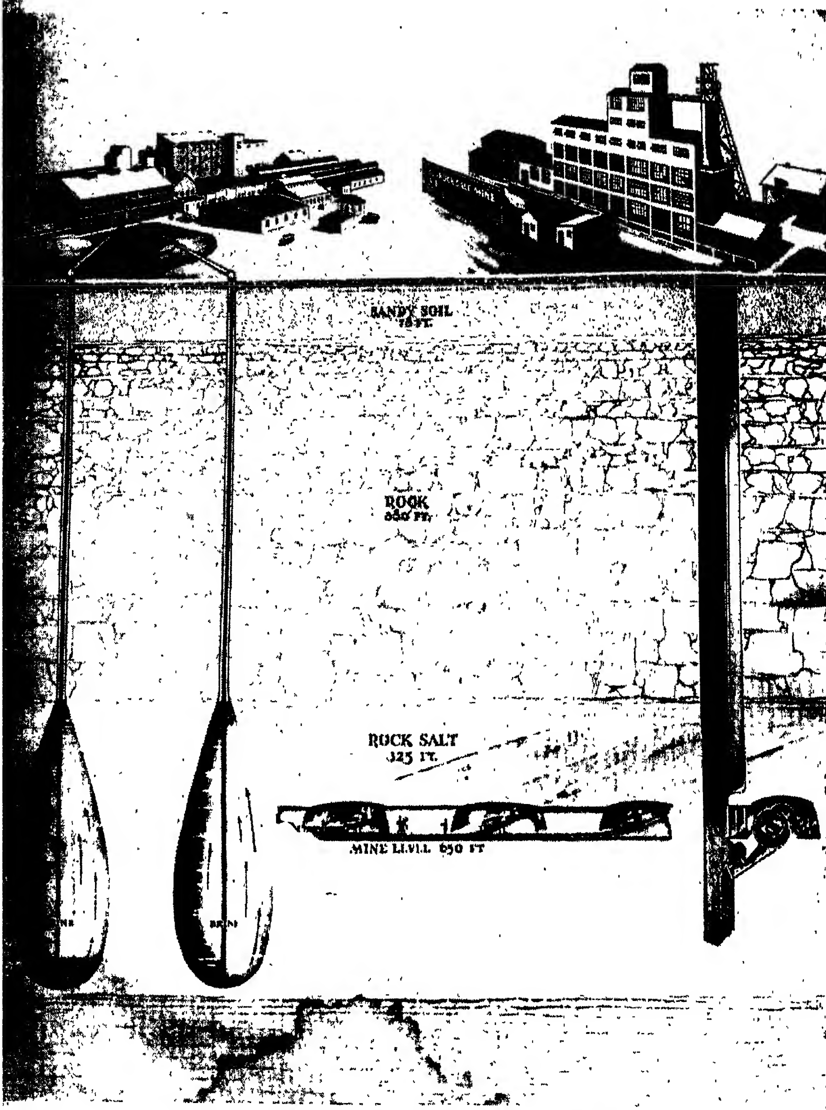


FIG. 1.—Idealized Cross-Section of Kansas Salt Wells and Salt Mine. Courtesy, The Carey Salt Company, Hutchinson.

Of this huge tonnage, the United States produced some 26 per cent of the total and was by far the greatest producer of this basic

raw material. Next in order of importance were Germany (12%), China (11%) and the United Kingdom (10%).[2]

The meaning of the above figures is indicated in the statement of Harris and Tucker of the United States Bureau of Mines:

> Because salt is the basic raw material of the important alkali chemicals, the world distribution of supplies has significant implications. If the United States had not possessed a virtually inexhaustible salt supply as well as a great chemical industry during the last half decade our country would have been seriously handicapped during the war. Moreover, it was Germany's large salt resources and well-developed chemical industry that enabled it to obtain substantial foreign credits through export of large quantities of salt and sodium compounds derived therefrom.[3]

The German resources mentioned in the quotation above include the world famous Stassfurt deposits, in which the salt beds reach thicknesses of three to four thousand feet and are overlain by valuable quantities of potassium salts which made Germany the master of the world supply of potash, so indispensable to agriculture, before the advent of World War I.[4]

Toward the close of World War II, however, Germany became so hard-pressed for bomb-proof manufacturing and storage space that many of her important salt mines were used for such purposes, thus greatly curtailing her salt producing capacity.[5]

Japan, on the other hand, had only limited and small resources of salt on her home islands and the need for salt in producing an extensive chemical industry was one of the factors that set Japan upon her vain and ghastly attempt at super-empire. In fact, it was reported that during the summer of 1940, Japan had made trade agreements to import salt from New Orleans and the West Indies. During the war, she made attempts to develop the salt resources of her territories and conquered countries in an effort to supply its need for greatly expanded war industries.[6] The difficulties encountered by our foe in meeting the need of this basic material was another of the many factors contributing to Japan's ultimate collapse.

In this brief survey of world production, it should be mentioned that Brazil has found large salt resources in recent years. Plans to establish an alkali chemical industry by our southern neighbor are

---

[2]These figures are compiled from the source cited in note 1 where it is also *estimated* that the United States was producing 43 per cent of the world's total salt production in 1944.

[3]Harris and Tucker, *Salt, op. cit*, p. 10.

[4]An excellent description of the Stassfurt deposits is given by B. Leslie Emslie "The Stassfurt Potash Salts," *Journal of the Society of Chemical Industry*, v. 28, pp. 393-398 (1909).

[5]*Minerals Yearbook 1944* (Washington, 1946), p. 1493; Harris and Tucker, *Salt, op. cit.*, p. 11; see also Thomas C. Howe, Jr., *Salt Mines and Castles*, (Bobbs- Merrill, 1946).

[6]*Minerals Yearbook*, 1940, p. 1375; Harris and Tucker, *Salt, op. cit.*, p. 13.

now being pushed forward.[7] Data on salt production in Russia under the Soviet government has been unobtainable and none of the recent lists of world production of salt include mention of salt of Russian origin.

Salt Production in the United States

The Federal government scarcely had been organized before data began accumulating on salt production. The well-known salt springs in the neighborhood of Syracuse, New York, were worked as early as 1788 or 1789 and data on salt production in New York, the first state to produce salt, have been kept since 1797.[8] In that year the salt production was recorded as 713 short tons.[9] In 1945, salt "sold or used by producers in the United States"[10] had risen to the huge figure of 15,394,141 short tons with a reported valuation of slightly more than 46 millions of dollars.[11]

Of this great quantity of salt, 97 per cent was produced by nine states as follows:

TABLE I.—*Production of Salt by States, 1945.*[12]

State	% of Total	Short Tons	Value
1. Michigan	28	4,285,493	$14,942,443
2. New York	19	2,862,224	10,327,013
3. Ohio	18	2,764,926	3,997,759
4. Louisiana	12	1,867,689	4,465,643
5. Texas	7	1,100,791	3,490,820
6. Kansas	6	855,806	3,837,850
7. California	4	694,609	3,424,711
8. West Virginia	2	370,260	903,759
9. Utah	1	122,997	363,997
Other States	3	446,853	213,175
Totals	100	15,394,141	$46,069,064

Kansas thus ranks sixth in output and fifth in the value of all salt produced in the United States.

General nature of salt sources.—The major salt deposits of the United States lie at some depths below the surface of the earth. In the arid Southwest, however, surface deposits of salt are found, especially in Nevada, Arizona, New Mexico, and western Texas.[13] In addition, evaporation of inland sea and lake water, as well as of ocean water, is also utilized as a source of salt but the total quantity obtained by such methods is a relatively small fraction of the total production.

It is also a fact that in localities where deep salt beds have been found, salt springs, marshes and shallow brine wells are also found. For example, salt springs were known in the region of Syracuse,

[7] Harris and Tucker, *Salt, op. cit.*, p. 10.
[8] W. C. Phalen, *Salt Resources of the United States* (U. S. G. S. Bulletin No. 669, Washington, 1919), p. 15.
[9] Phalen, *Salt Resources*, etc., *op. cit.*, p. 264.
[10] "Salt sold or used by producers in the United States" is the literal designation used in official reports on salt. This term is hereafter more simply called "production" in this review.
[11] Harris and Tucker, *Salt, op. cit.*, p. 3.
[12] Harris and Tucker, *Salt, op. cit.*, p. 3.
[13] Phalen, *Salt Resources*, etc., *op. cit.*, p. 14.

New York, for possibly several hundred years before a bed of rock salt 45 feet thick and over 1,200 feet below the surface was found by drilling in 1888. The same situation is true in central Kansas for salt springs and marshes were known long before the discovery in 1887 of deep beds of crystalline salt in the state.

In Michigan, the greatest producer in the country, salt is obtained as rock salt, and as natural brine; in the latter case, the brine is used as such without actual recovery of salt, a fact which is also true of brine production in New York and Ohio. In composition, brines from some Michigan salt wells, contain in addition to common salt, sufficient proportions of bromine, calcium and magnesium to serve as sources of these elements.[14]

Salt production in New York is confined chiefly to rock salt and artificial brine. In composition, salt from such sources does not differ greatly from that obtained in Kansas save that it shows occasionally a small bromine content not observed in Kansas salt.

Ohio salt is obtained chiefly from brines, artificial and natural, some brines serving as sources of bromine and of calcium chloride.[15] Salt from Louisiana and Texas is recovered as rock salt and brine. Texas brines from certain localities are used as sources of magnesium and detectable quantities of potassium have been found in other Texas brines. The largest reserves of potassium in the country, however have been located in salt beds which continue from Texas into New Mexico.[16] Among the salt beds reported in Louisiana and Texas are two having thicknesses greatly exceeding any other in the country. One in Louisiana has a reported thickness of 2,740 feet and another occurs in Texas (Harris County) where a boring penetrated 5,000 feet of rock salt without reaching the bottom of the bed.[17]

Salt in Kansas is produced commercially by mining rock salt and by the production of artificial brines. In composition, it is free, as far as present analyses have shown, of bromine and of potassium (save for a few scattered cases to be discussed later) and of calcium in quantities sufficient to make the Kansas salt bed sources of this element. Calcium is present, however, in sufficient quantities in

---

[14]Phalen, *Salt Resources*, etc.; *op. cit.*, p. 44. Phalen (pp. 216-249) gives numerous analyses of "salt" from various salt producing centers of the United States and any reference to salt composition not otherwise cited in the text is based on Phalen's report.

[15]Phalen, *Salt Resources*, etc., *op. cit.*, p. 67; *Minerals Yearbook 1944*, pp. 1508, 1509.

[16]*Minerals Yearbook 1944*, p. 1457; John E. Conley and Everett P. Partridge, *Potash Salts from Texas-New Mexico Polyhalite Deposits* (U. S. Bureau of Mines Bulletin 459) Washington, 1944, pp. 6-14.

[17]The Louisiana figure is reported by Phalen, *Salt Resources*, etc., *op. cit.*, p. 105 and the Texas deposit by E. H. Sellards and C. L. Baker, *The Geology of Texas*, vol. 2, (University of Texas Bulletin 3401) Austin, Texas, 1934, p. 622. Incidentally both the thick Louisiana and Texas deposits occur in salt domes which are extrusions of salt from underlying salt beds (see page 228) into strata above, as the result of compressive earth movements.

Kansas salt to produce some difficulties in the purification of common salt.[18] A brief discussion of the chemistry and geology of inland salt deposits will throw some light on the character of Kansas salt beds, especially in their relation to other salt deposits in this same general region.

If the reader becomes confused, however, by the use of the terms *salt, salts, common salt, halite, saline deposits* and *salt beds,* we can stop for a moment and try to straighten out the difficulty. A *salt* (plural *salts*) is a term meaning a substance composed of a metal and certain non-metals. Thus common salt, the best known *salt,* chemically is known as sodium chloride, a compound of the metal, sodium, and the non-metal, chlorine. If sodium chloride occurs as a mineral, as it does in salt beds, mineralogists have adopted the term *halite* or *rock salt* as the name of common salt. Salt beds, or saline deposits, usually contain a number of salts although common salt (halite) is usually by far the most abundant mineral in a salt bed. However—and this point is probably the most confusing one—if the term *salt* (singular, not plural) is used without other qualification, sodium chloride (common salt, halite) is the substance usually meant.

Chemistry and Geology of Deep Inland Salt Deposits

Most of the great salt deposits of the world are now believed to have arisen from the evaporation of ancient seas or partially detached arms of seas. One important link in the chain of evidence for this belief is a comparison of the composition of the solids in present ocean water with that of salt deposits. About three and a half per cent of ocean water consists of dissolved solids and the analysis of ocean water from many sources and by many analysts give results which do not differ greatly from each other. Average values of well over a hundred such analyses for the solids of ocean water give:

TABLE 2.—*Composition of Solids from Ocean Water.*[19]

Chlorine (as chloride)	55.2%
Sodium	30.6
Sulfate	7.8
Magnesium	3.6
Calcium	1.3
Potassium	1.2
Carbonate	0.2
Bromine (as bromide)	0.1
	100.0%

(Common salt, sodium chloride, contains 60.7% chlorine, 39.3% sodium)

[18]It should be observed that natural brines occur in Kansas but so far have not been utilized. Such brines are secured from oil wells—chiefly deep oil wells— in a number of Kansas localities. Extensive chemical analyses of such brines by R. Q. Brewster and C. A. Vander Werf show a relatively high magnesium content and in some cases lesser amounts of bromine and potassium although sodium and chlorine are still the important elementary constituents. The possibility of using these brines as a source of magnesium has been considered by W. H. Schoewe, *Kansas Oil Field Brines and Their Magnesium Content,* State Geological Survey of Kansas, Bulletin 47, Part 2, July, 1943, pp. 41-76. The analyses of Brewster and Vander Werf are included in this bulletin.

[19]Based on F. W. Clarke, *The Data of Geochemistry,* 5th ed., U.S.G.S. Bulletin 770, (Washington, 1924), p. 127.

The analyses of dissolved solids in the waters of Great Salt Lake give results not markedly different from the above values but it must be remembered that the waters of this inland sea are far more concentrated with salt than are the waters of the open oceans. (Total solids in Great Salt Lake average about 19.5% as against 3.5% for ocean water.)

As against the above values one may cite analyses of rock salt and the solids in natural brine selected more or less at random from many data.[20]

TABLE 3.—*Composition of Rock Salt and Brine.*

	New York (rock salt)	Ohio (natural brine)	Kansas (rock salt)
Chloride	59.6%	61.1%	60.0%
Sodium	38.9	23.2	38.6
Sulfate	1.2	......	0.8
Magnesium	0.1	2.4	0.1
Calcium	0.2	11.4	0.4
Potassium	Trace	1.2	0.1
Carbonate	......	......	......
Bromide	......	0.7	......
	100.0%	100.0%	100.0%

That the analyses of ocean water solids and salt beds do not agree exactly is not surprising for the conditions of deposition are complex indeed.

To illustrate this point consider two salts, say potassium chloride and sodium chloride. If these salts are dissolved in water in the same ratio that sodium and potassium exist in ocean water and the resulting solution evaporated at constant temperature to dryness, the following results have been observed. The solution, as it lost water, would become more concentrated in both salts and finally sodium chloride (common salt) would crystallize out, thus increasing the proportion of potassium chloride in the solution. Finally a condition would be reached, after the long continued crystallization of sodium chloride, when the solution would become saturated with potassium chloride and this substance would then also crystallize. Continued removal of water (evaporation) would cause both salts to crystallize out together until all the water had been removed. The dry deposit remaining would then contain a bottom layer of sodium chloride and an upper layer of potassium chloride mixed with common salt.

To take a second illustration, let us assume that potassium and magnesium chlorides are dissolved in water in the same proportions and concentrations in which potassium and magnesium occur in sea water. If such a solution is evaporated at constant temperature the

[20]Phalen, *op. cit.*, p. 216 (analysis No. 2 and 7); p. 228 (analysis No. 5).

following series of changes take place. The solution will finally become so concentrated that solid potassium chloride will first crystallize. Further evaporation will cause the separation of a new solid, carnallite, a double chloride of potassium and magnesium ($MgCl_2 \cdot KCl \cdot 6H_2O$). Continued evaporation will then cause all the original potassium chloride to disappear (forming carnallite) but eventually, as still more water is evaporated from the solution, a crystalline hydrated magnesium chloride ($MgCl_2 \cdot 6H_2O$) would appear and this salt would crystallize out with carnallite as the water finally disappeared.

These two examples have been given as they show some of the chemical peculiarities which occur when solutions are evaporated and to emphasize the point that the resulting solid which remains upon the evaporation of the water will have different compositions at different levels and will not be of the same uniform composition throughout as was the solution from which it was produced.

But sea water, be it recalled, in addition to containing sodium, potassium, magnesium and chlorine, contains calcium and sulfate as well and all in one solution. The minerals chemically possible and the order in which they crystallize is now greatly complicated as compared to the relatively simple cases when only two were originally present. As a matter of fact, well over a dozen minerals, containing the above elements in varying combinations, have actually been identified in the salt beds deposited by the evaporation of sea waters. In addition, the nature and order of precipitation will also depend upon the temperature at which evaporation takes place, which in a natural process such as the evaporation of ocean water, will vary greatly. However, the problem of the nature and order of precipitation of salts from solutions having the approximate composition of sea water has been worked out in great detail, from a purely *chemical* standpoint, by the great Dutch physical chemist, van't Hoff.[21]

van't Hoff advanced his studies of salt deposition as an explanation of the German salt deposits at Stassfurt mentioned previously and found that they were in agreement with the order (see Figure 2) in which minerals, which could arise from the evaporation of ocean water, were actually found. If the great Dutch chemist's work could be applied without other considerations than purely chemical ones,

---

[21]For a review of van't Hoff's work in connection with the problem of the oceanic salt deposits see Alfred W. Stewart, *Some Physico-Chemical Themes*, London, 1922, pp. 60-82; see also F. W. Clarke, *Data of Geochemistry*, U.S.G.S. Bulletin No. 770, Washington, 1924, chapter VII.

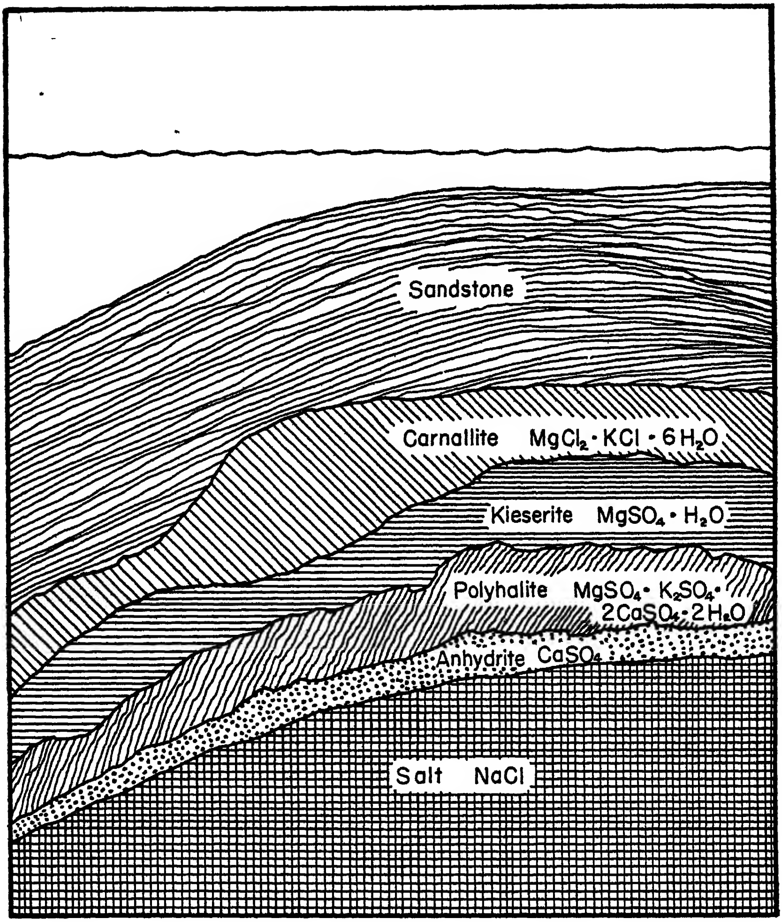


FIG. 2.—The Stassfurt Deposits, redrawn after Stewart. It must be recalled that common salt is present in all beds and even the lowest salt bed (NaCl) is not pure sodium chloride but is interbedded with anhydrite. Hoots states "There is no apparent reason to believe that conditions in western Texas were greatly unlike those that attended the deposition of the Stassfurt beds."

one could even deduce the temperatures at which the various beds of minerals were laid down.

That the problem of salt deposits from ancient seas is far from a purely chemical one, however, is all too apparent if we stop to reflect on the possible geologic processes which accompanied the purely chemical ones. Some of these added complications would include a consideration of seasonal changes; of irregular and varying atmospheric conditions of humidity and of temperature during de-

position of the salt beds; of long dry periods interrupted by more humid ones. In the later case dilution of sea water as a result of rains, and the influx of streams laden with silt, would produce their records in the salt beds. Further, to produce these deep and thick salt beds would require the evaporation of enormous quantities of sea water. Thus to produce a foot of salt from a solution similar in composition to present ocean water would require the evaporation of 80 feet of water![22] Deposits of salts hundreds and thousands of feet thick would of necessity require long periods of time during which many other physical changes could occur.

Then, too, once the salt was deposited and covering and protecting layers of shale, rock and sand laid down over the salt beds, re-solution by underground waters, recrystallization in new localities, other and new chemical reactions, changes produced by the pressure of overlying strata, and faulting and folding of strata are additional factors which the care-free chemist leaves to the over-taxed geologist to take home at night and torment him in his dreams.

Still another factor, and an important one, would be the movement of large land masses during evaporation, especially near the final dessication stage. Let us return for a moment to the illustration of the evaporation of the solution of potassium and sodium chlorides described on page 229. As there pointed out, sodium chloride would precipitate out first followed eventually by the precipitation of a *mixture* of common salt and potassium chloride. Imagine that evaporation had taken place in a vessel whose depth gradually became greater toward its center; a situation similar to a large and shallow sea. Salt depositing first over the bottom of the vessel and up to its sides, would gradually force the residual solution—becoming richer in the potassium salt—toward the center and deeper portion. Final dessication (drying up) would leave the potassium chloride (mixed with sodium chloride) in the center of the vessel and near the top of the dried salts. If our vessel were a shallow sea and land movement occurred toward the end of dessication, the potassium salt might actually be drained away from the rest of the salt bed and deposited in another area; and thus the potash deposit may be far removed from the "center" of the dried up sea. Such a

---

[22]This figure is based upon an average composition of ocean water as 3.5% solids of which 78% is sodium chloride; an average density of ocean water of 1.03 gm/cc and density of solid sodium chloride equal to 2.2 gm/cc. N. H. Darton "Permian Salt Deposits of the South-Central United States" *Contributions to Economic Geology* (U.S.G.S. Bulletin 715) Washington, 1921, p. 223, states that 100 feet of sea water deposits "about 3 feet of sodium chloride" but the basis of his calculation is not indicated. It is the writer's guess that Darton failed to take into account the density of solid sodium chloride.

condition may have arisen in connection with the potash deposits in Texas.[23]

Despite all these complexities, the fact remains that in the great salt deposits which have been carefully studied, potassium compounds occur near the top of the salt beds, or nearby areas, (see Figure 2) mixed with halite, (common, or rock, salt) and overlying the thicker deposits of common salt which of necessity must be present if the ancient seas had a composition approximating modern ones. It is also a fact, that whatever the mineral that occurs in the salt beds, halite is invariable present and mixed with it.[24]

The above discussion may have suggested to the reader that deposition of salt beds took place in a single geologic age. As a matter of fact, salt deposits in this country not only have a wide and abundant geographic distribution but a wide geologic distribution as well. The following table from Phalen[25] will illustrate this point.

TABLE 4.—*Geographic and Geologic Distribution of Salt in the United States.*

Time		*Locality*
Recent		Salt formed or forming in inland seas: Great Salt Lake, Utah; Lake at Zuni, N. Mex.; Owens, Searles, and Mono lakes, Calif.; alkali lakes of Oregon; salt plains or marshes in Oklahoma; trans-Pecos region of Texas, Nevada, New Mexico, Utah, Calif.; widely scattered salt springs in western states.
Tertiary		Salt domes of Louisiana and Texas (part of Louisiana deposits are Quaternary and possibly late Cretaceous); deposits near Idaho-Wyoming border; Virgin River valley, Nev.
Jurassic		Sevier Valley, Utah.
Carboniferous	Permian	Kansas, Oklahoma, northwestern and western Texas, eastern New Mex.
	Pennsylvanian	Along Ohio River near Pomeroy, Ohio, and Mason and Hartford, W. Va.; Malden, W. Va.
	Mississippian	Saginaw Valley, Mich.; Saltville, Va.; Pittsburgh, Pa.
Silurian		New York, Michigan (excluding Saginaw Valley), northern Ohio.

[23]G. R. Mansfield and W. B. Lang *"The Texas-New Mexico Potash Deposits" The Geology of Texas,* vol. 2 (University of Texas Bulletin 3401) Austin, 1934, p. 682. Few people, even chemists, recognize the significance and importance of these potash deposits found in Texas and New Mexico. At Carlsbad, New Mexico, sylvite (potassium chloride) is being mined and the potash reserves in this region are estimated at 75,000,000 tons of K_2O. Still other reserves must be found, however, for it has been estimated that ten or fifteen years will see a considerable depletion of our present reserves. It is of interest to the chemist to know that rubidium and cesium (the former in amounts equal to 0.5 per cent (calculated as oxide) of the vein in which it was found) have been discovered in the Carlsbad deposits. (*Minerals Yearbook 1944,* pp. 1457, 1458, 1463). For a general review of potash in the United States see the "Symposium on Potash" *Industrial and Engineering Chemistry,* v. 30, pp. 853-896 (1938).

The only other below surface potash reserves recently discovered are the Russian Solikamsk deposits reported "as the most extensive known in the world" and which may give rise to the world's largest potassium industry. (Alexander Fersman, "Science in the U.S.S.R.," *Advancement of Science,* v. 3, No. 9, Sept., 1944, pp. 62-77).

[24]These general conclusions are based on the description of the Stassfurt deposits given by Emslie (see note 4); by the statement that the Texas-New Mexico "potash-bearing salts form only a fractional part of the *upper* [italics are the writer's] division of the great salt-bearing series" found in the paper by Mansfield and Lang cited in note 23, p. 678; and the statement that "Halite is by far the most abundant mineral, making up at least three-quarters of the saline portion of each core" of many drill cores examined in the extensive study by W. T. Schaller and E. P. Henderson *Mineralogy of Drill Cores From the Potash Field of New Mexico and Texas* (U.S.G.S. Bulletin 833), Washington, 1932, p. 7.

[25]Phalen, *Salt Resources* etc., *op. cit.,* p. 193.

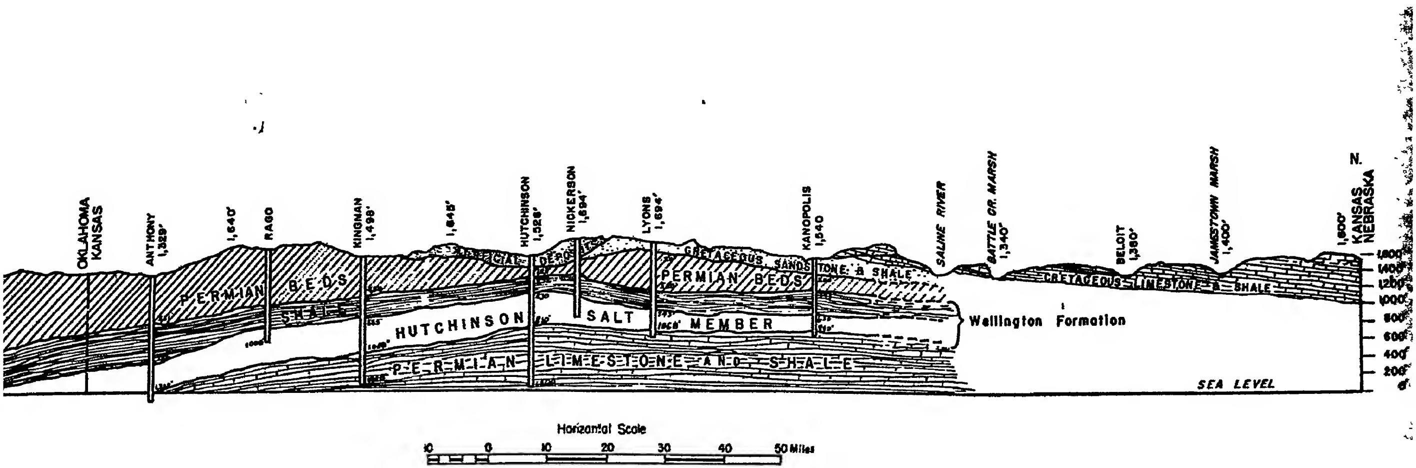


FIG. 3.—North-south generalized cross-section through Kansas showing the Hutchinson salt member in its relation to Hutchinson, Lyons and Kanapolis, the salt producing cities of Kansas. Redrawn after Haworth and Kirk, 1898. The upper section labeled "Permian Beds" are the famed Red Beds, well known to the geologist.

Geology of Kansas Salt Deposits.—The deep Kansas salt deposits are of Permian age (Table 4), and belong to the Hutchinson salt member of the Wellington shale formation as can be seen in cross section by reference to Figure 3.

In Permian time, a great shallow sea, or succession of seas, covered nearly all of present central Kansas and extended south and westward across present Oklahoma, southern and western Texas, and southeastern New Mexico.[27]

To quote from Smith's excellent summary[28]

> The Permian Sea was not a single, unchanging water body covering the salt basin that extended through Kansas to southern Texas. In the long period represented by Permian time, it consisted of a succession of seas, the shore lines of which may have changed greatly and at different times, from the beginning of deposition of the salts until the last of them was covered by clay and sand. The order of deposition was calcium carbonate, calcium sulfate (mostly in the form of anhydrite), and then sodium chloride, with potash and magnesium in the mother liquors. From time to time after the first anhydrite was deposited, the salinity of the water changed; in some areas only anhydrite was deposited for long periods. Some gypsum [hydrated calcium sulfate] was also deposited. Many minor changes in conditions of deposition are shown by the varying sequences of anhydrite, salt and clayey material. The anhydrite at or near the surface has been hydrated to gypsum.

It seems quite possible that the Permian sea in Kansas was, if not completely, at least nearly cut off from the southern portions of the sea by Permian mountains in present southern Oklahoma and the Texas Panhandle[29] and Bass has suggested further[30] that a possible axis of uplift in southern Kansas and northern Oklahoma may

---

[26]The nomenclature in use at the present time will be found in *Tabular Description of Outcropping Rocks in Kansas,* R. C. Moore, J. C. Frye, and J. M. Jewett, State Geological Survey of Kansas, Bulletin 52, Part 4, October, 1944, pp. 160 and 162.

[27]The geology of Kansas salt springs and marshes has not been investigated for many years. Robert Hay "Geology of Kansas Salt" *Seventh Biennial Report Kansas State Board of Agriculture,* Topeka, 1891, Part II, pp. 83-96, devotes a section to salt marshes and concludes that the "saltiness" of the northern marshes is produced by salt occuring in shales much younger than Permian, possibly Cretaceous. The salt of more southerly Kansas salt marshes or springs, Hay believed to be of later origin, "a relic of closing Permian time," especially Geuda Springs in Sumner County. Erasmus Haworth "Geology of Kansas Salts" *Mineral Resources of Kansas 1898,* Lawrence, 1899, p. 86, also concludes that the salt of Kansas salt marshes and springs is of much more recent origin than Permian. The salt in Geuda Springs, however, Haworth ascribes to solution of salt from the Hutchinson salt member.

F. W. Cragin, "The Permian System in Kansas," *Colorado College Studies,* v. 6, March, 1896, pp. 1-52, has also discussed in some detail the geology of Kansas salt and distinguished between two salt measures in the Permian, a *lower* and an *upper.* The *lower,* Cragin called the "Geuda Salt Measures" (which corresponds to that known at present as the Hutchinson Salt Member) from its outcropping at Geuda Springs, Sumner County. The *upper,* Cragin specifies as the "Salt Plains Measures" which gives rise to the salt plains of Oklahoma near the southern Kansas boundary. C. N. Gould, "The Oklahoma Salt Plains," *Transactions Kansas Academy of Science,* v. 17, 1901, pp. 181-184, discusses further Cragin's "Salt Plains Measures."

In addition to the sources of information on the geology of Kansas salt cited above, I have used the following sources in the discussion which follows in the text; N. W. Bass, *Geological Investigations in Western Kansas,* Bulletin 11, State Geological Survey, Lawrence, April, 1926, Part IV, "Structure and Limits of the Kansas Salt Beds," pp. 90-95; H. W. Hoots "Geology of a Part of Western Texas and South-eastern New Mexico with Special Reference to Salt and Potash," U.S.G.S. Bulletin 780, Washington, 1926, pp. 33-126; H. I. Smith "Potash in the Permian Salt Basin" *Industrial and Engineering Chemistry,* v. 30, pp. 854-860 (1938) and others specifically cited later in the text.

[28]Smith, *loc. cit.,* p. 855.

[29]Hoots, *loc. cit.,* p. 123.

[30]Bass, *loc. cit.,* p. 92.

have formed a barrier between two basins when salt deposition was in progress during Permian time. In general, geologists appear to agree that deposition of salt in Kansas began at an earlier period than it did in regions to the south and the Kansas salt deposits which are now worked commercially (in the Hutchinson salt member of the Permian) are older than those of western Texas and New Mexico.[31] Whether or not the Permian sea in Kansas became separated from its southern branch appears to the writer to be of considerable importance. If complete separation and complete evaporation occurred in the northern Permian sea in Kansas it would then appear reasonable that the valuable salts of potassium would of necessity have been present at sometime or other in the salt deposits of the Wellington formation. So far potassium has only been occassionally reported in analyses of Kansas salts.[32] As far as the writer knows no systematic exploration for potassium salts in Kansas has been made.[33]

There are, of course, several possibilities which may account for the absence of potassium salts in the Kansas salt beds thus far investigated. If, for example, the Kansas Permian sea, after depositing salt and anhydrite, but before becoming sufficiently concentrated to deposit potassium salts, were drained from the recently deposited

---

[31]Hoots, *loc. cit.*, p. 41; Mansfield and Lang *loc. cit.*, p. 677. Salt laid down in the Nippewalla group of the Permian is younger than that deposited in the Wellington formation, see p. 240.

[32]Extensive analyses of Kansas salt have been made, both of the rock salt and of salt obtained from the evaporation of brines. Some of these analyses have been published but by far the greater number are the private property of salt producing companies. Among the most extensive analyses published are those reported by Robert Hay, "Salt" *Sixth Biennial Report of the Kansas State Board of Agriiculture*, Topeka, 1889, Part 2, p. 196; E. H. S. Bailey "Salt in Kansas—Its Composition and Methods of Manufacture" *Eighth Biennial Report of the Kansas State Board of Agriculture*, Topeka, 1893, Part 2, pp. 167-180 and Phalen, *Salt Resources*, etc., *op. cit.*, pp. 228, 234, 246. Neither Hay nor Bailey report potassium in over fifty analysis; Phalen reports small quantities of potassium but concludes that even in Kansas bitterns (mother liquors remaining after considerable separation of salt) that the "content of potassium salts is too small to be of importance". However, Bailey made an analysis of rock salt from a boring made at Ellsworth, Kansas, in 1887, the year the salt beds were discovered, and reported 0.67 per cent as potassium chloride (*Trans. Kan. Acad. Science*, v. 11, p. 9, Topeka, 1889). It is to be observed, also, that of the several analyses reported by Phalen, the highest potassium contents recorded were from Ellsworth. Robert M. Horner, *The Salt Industry at Sterling, Kansas*, Master's thesis, University of Kansas, 1914, p. 57, analyzed brines from the Sterling salt well and stated that potassium chloride did not exceed 0.07 per cent of total solids. Mr. Paul V. Imes, chief chemist for the Carey Salt Company, kindly furnished me with a recent analysis (1944) of Kansas crushed rock salt as taken from the Carey mine at Hutchinson which gave

Acid insolubles (0.1 NHCl)	0.464%
Iron Oxide	0.008%
Calcium sulfate	1.933%
Magnesium sulfate	0.125%
Magnesium chloride	0.056%
Sodium chloride	97.414%
	100.000%
Water solubility	98.9%
Moisture content as received	0.04%

[33]Hoots, *loc. cit.*, p. 48, states that the Kansas State Geological Survey had made extensive studies to determine if potash (potassium salts) were present in the saline deposits of Kansas but had met with negative success up to 1926. The writer has found no report published on any such studies.

rock salt, the potassium-rich sea water would not have deposited potassium salts directly in the beds now called the Hutchinson salt member. If there were a number of Permian seas, as already suggested, such a process (caused by land uplift, the breaking of a barrier or by other methods) would have had to occur for each such sea. It is also possible that potassium salts were laid down with halite toward the end of the Permian seas in Kansas but were subsequently leached out by circulating underground waters. If the waters came from above, the potassium salts being more readily soluble and nearer the top of the salt beds, would be the first to disappear by solvent action, the underground water then flowing on and depositing the potassium salts at some other locality (possibly further west as the strata in the neighborhood of the salt beds dip toward the west).[34] In either of the two possibilities suggested above, potassium compounds would be removed and deposited elsewhere, although recently (1938) H. I. Smith[35] has reported that polyhalite (a potassium bearing mineral) has been found in minute quantities in Trego and Stafford Counties, within the salt belt. As polyhalite has been previously unreported the significance of this discovery remains to be explained.

[After the above discussion was written and set in type a letter was received from Mr. R. R. Sayers, director of the U. S. Bureau of Mines (December 17, 1946), describing potash investigations by the Federal government as late as 1944. These investigations are now in the course of publication but the pertinent information contained in Mr. Sayers' letter reads as follows: "Core drilling to investigate potash deposits was conducted by the government under Bureau of Mines supervision from 1927 to 1929 in eastern New Mexico and west Texas, and in 1944 in eastern New Mexico. No drilling was done in Kansas, but from data gained by privately drilled oil and gas wells, it is well established that the general potash-bearing formation extends into Kansas."]

That great quantities of halite (sodium chloride, rock salt, common salt) were laid down in Kansas during Permian time is apparent from the isopachus map of Figure 4. This map[36] shows not the

[34] H. T. U. Smith, *Geologic Studies in Southwestern Kansas*, State Geological Survey Bulletin 34, Lawrence, 1940, pp. 131, 168-170, reviews the literature on "sinks" observed in the territory above the salt beds and points out that some are believed to have occurred by the solution of the salt beds and the subsequent collapse of the overlying structures. It could again be pointed out that potassium salts lying near the top of the salt beds and being the most soluble would probably be the first to disappear and there is therefore the possibility that such sinks were caused by the solution of potassium salts.

[35] H. I. Smith, *loc. cit.*, p. 860.

[36] An original isopachus map was published by Bass in 1926, *op. cit.*, p. 91, Plate VIII. Bass revised this map in 1932 and it was published separately by the State Geological Survey. Still more recent data revise the over-all area covered by the Permian salt deposits as is shown in **Figure 5.**

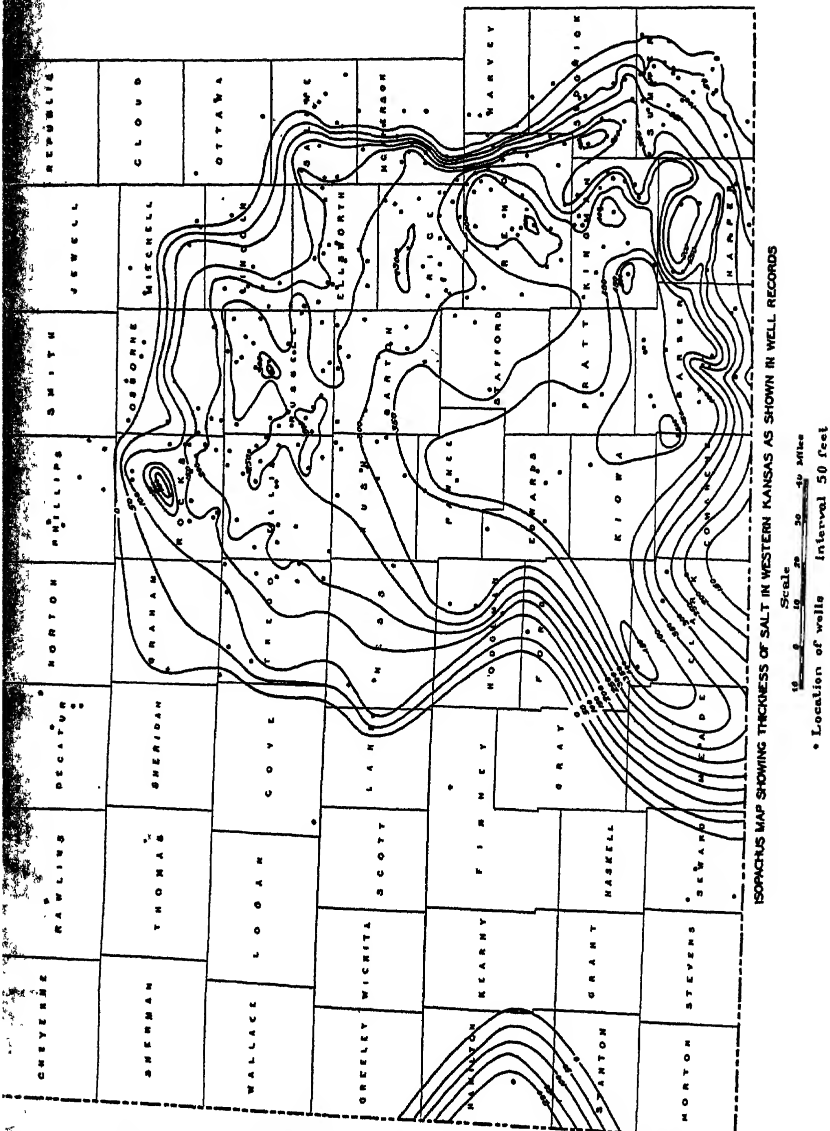


FIG. 4.—The Isopachus Map of N. W. Bass, 1932. Courtesy, State Geological Survey, Lawrence. Note that the contour lines give no indication of the depth below surface of the salt beds, but simply show the thickness. In addition, the salt beds are not pure salt but are interbedded with shale and calcium sulfate.

depth below surface of the salt beds, but a continuous line marks the thickness of the salt beds, i.e., the lines show deposits of beds of equal thickness. Thus the small completely enclosed line marked 450

in northwest Clark County means that beds of thickness of 450 feet should be found on points lying on this line but the line gives no indication of the depth below surface at which the top of the salt bed is found. It should be noted, too, that the indicated thicknesses given by these isopachus lines, give the total thickness of strata which contains salt. The salt layers, however, are interbedded with layers of calcium sulfate or shale. Even if 50 per cent of the thicknesses indicated by each isopachus line was common salt, the total salt underlying Kansas would still be enormously large. In fact, the State Geological Survey estimates the salt reserve in Kansas to be 5,000 billion tons, a quantity which at the present rate of consumption of total salt would be sufficient to supply the United States for about a half million years.[37]

If we assume that it took 80 feet of sea water to produce one foot of salt (see page 232), one can but faintly imagine the thousands of years that past uncounted by as these Kansas salt beds slowly accumulated; accumulated in an age that reaches into a Kansas past so long ago that time, as we now count it, has but little meaning.

Figure 5 shows the areal extent of salt beds below the surface of central and south-western Kansas. Comparison with Figure 4 will show that the areas indicated are not identical. There is, however, a ten year interval between the preparation of the two maps (1932 and 1942) and a considerable fund of information, as the result of extensive drilling for oil, had been added to our store of knowledge in this period. One of the notable differences in the two maps is the increase in the area underlain by salt in extreme southwest Kansas. These salt beds are of more recent origin than those in the Hutchinson salt member (see Figure 3). In fact the newer salt beds overlie in part those of the Hutchinson member as can be seen by examination of Figure 5.[38] Only salt beds in the Hutchinson member of the Wellington formation are now worked commercially and it is therefore these beds which are of greatest general interest. As can be seen from the isopachus map (Figure 4) the eastern edge of the Hutchinson salt member drops rather steeply. At one place near the eastern edge, wells reporting 200 feet of salt are only a few miles west of wells reporting no salt. Bass[39] suggests that the sharper eastern edge has been produced by effects on the original salt deposit comparable to erosion; the edges, therefore, do not mark the

---

[37]J. M. Jewett in *Kansas Mineral Resources for Wartime Industries*, State Geological Survey Bulletin 41, pl. 3, Lawrence, Kansas, 1942, p. 152.
[38]These newer salt beds still belong to the Permian but lie in the Nippewalla group (see Jewett, *loc. cit.*, p. 150).
[39]Bass, *loc. cit.*, p. 93.

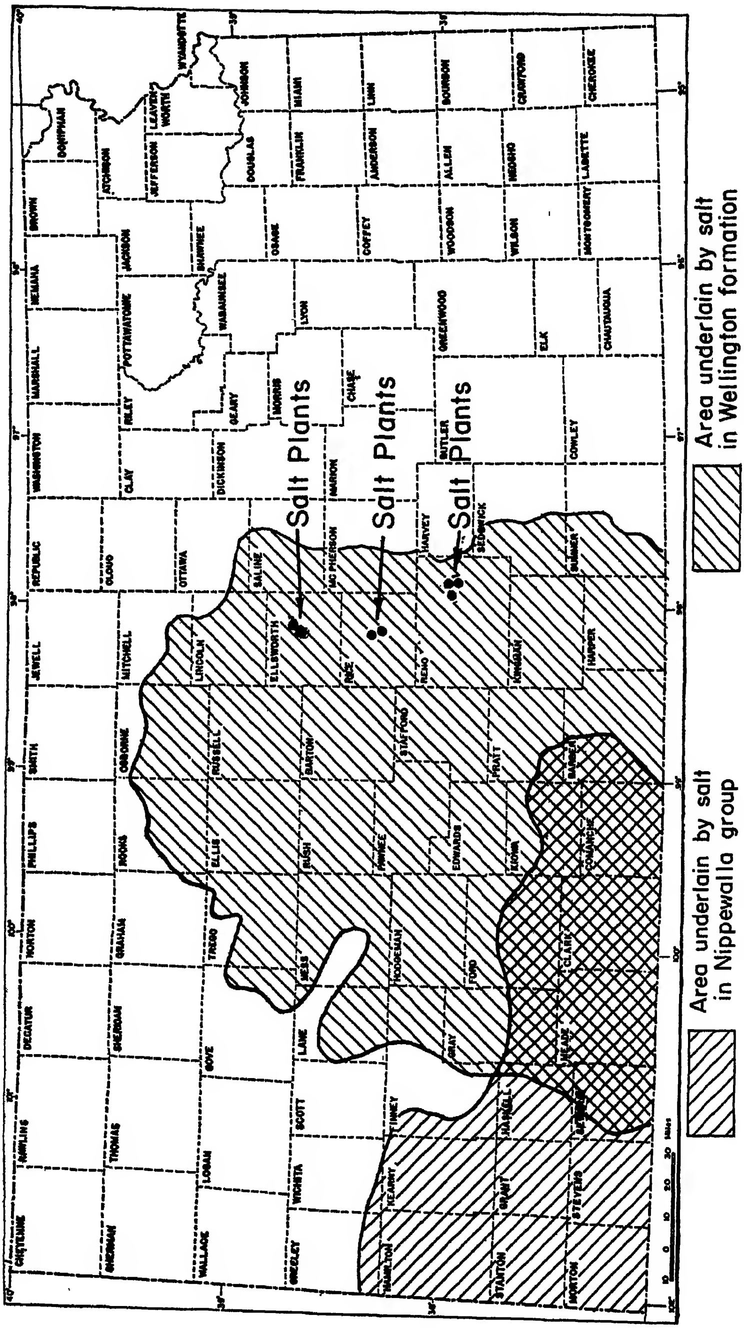


FIG. 5.—Areal extent of the two deep salt deposits of Kansas. From Kansas Mineral Resources For Wartime Industries, 1942. Courtesy, State Geological Survey.

original shore line of the salt as it was first laid down. A possible cause of this effect would be solution of the salt by ground waters followed by circulation of the resulting solution; the original beds would therefore have extended further eastward. Leaching (solution) by ground waters, Bass suggests, on a large scale as indicated by this hypothesis, would produce settling of the overlying shale and a change in the surface topography. Bass even suggests that the extensive Cheyenne Bottoms in Barton County may have arisen by this cause.[40]

To the west, the "contour intervals" of the isopachus map (Figure 4) thin out and Bass regards the western edge of the Hutchinson salt member as the shore line of the original salt deposits.

This salt member also dips gently to the west and as the surface altitude to the west becomes higher, it follows that the salt beds lie farther below the surface on their western edge than on the east.[41] The depth of the shafts used in mining rock salt vary considerably with locality. At Hutchinson, shafts have been driven some 600 feet to reach the top of the salt beds; at Lyons about 1,000 feet and at Kanopolis about 800 feet (see page 244 for exact data). All of these localities are near the eastern edge of the salt deposits. In logs of oil wells in the northwestern part of Hodgeman County, near the western edge of the salt beds, salt was not encountered until the drill had reached a depth of 1800 feet.[42]

Methods of Salt Production

As already pointed out, salt is produced by evaporation of sea water, by mining rock salt or by pumping from the ground natural brines or artificial brines made from salt bearing strata beneath the surface. Evaporation of salt brines will be discussed under purification of natural salt. The pumping of natural brines presents no principles of production different than pumping problems in general, taking into account however, the nature of the solution to be pumped.

The two remaining methods, mining of salt and the preparation and pumping of artificial brines involve some factors that make their discussion worth-while, especially as these two methods are the only ones used in the production of Kansas salt.

Veitch[43] has recently given an excellent description of mining salt and a brief review of his article may be given here as it prob-

---

[40]See also the review by H. T. U. Smith in note 34 and the suggestion considering the cause of "sinks" given there.
[41]Jewett, *loc. cit.*, p. 151.
[42]Jewett, *loc. cit.*, p. 151.
[43]W. M. Veitch, "Mining Salt Beneath the Kansas Prairies" *The Explosives Engineer*, September-October, 1943, pp. 180-183, 198. Mr. Veitch is superintendent of the Morton Salt Company, Kanopolis, Kansas.

ably represents the general methods employed in mining salt in this region.

A shaft is sunk to the salt bed to be mined and of sufficient size to install elevators that are capable of hauling salt loads of

FIG. 6.—Drilling Holes for Dynamite Blasting in the Face of a Salt Room, Morton Salt Company Mine, Kanapolis. Note the "layers" of salt interbedded with shale and calcium sulfate. Courtesy, Mr. W. M. Veitch, Superintendent.

several tons. The depth of the shaft depends, of course, upon the depth of the salt bed to be mined which in Kansas ranges from 600 to 1000 feet. Rooms radiating from the shaft are then cut in the salt bed. In the mine of the Morton Salt Company at Kanopolis, the salt beds are approximately 800 feet below the surface and a salt bed some 8½ feet in thickness, selected because of its purity of salt, is worked and rooms are cut in the salt bed 300 feet long by 40 feet wide. The centers of two adjacent rooms are 80 feet apart thus leaving pillars of salt 40 feet in thickness as supporting members. Main haulageways for the broken salt are also made forty feet wide. The salt beds are undercut at floor level for a distance of 40 feet by electrically driven saws to a depth of eight feet. Thirty two holes are then driven in the 40 foot face (which is now about 8 feet in height as the width of the undercut is some six inches) to accom-

modate explosive cartridges seven inches long and one and a quarter inches in diameter. The cartridges are spaced in four rows in carefully designed positions and are fired in definite sequences so that maximum shattering effect but the minimum scattering of the salt is thereby secured. After blasting, the salt is mechanically loaded

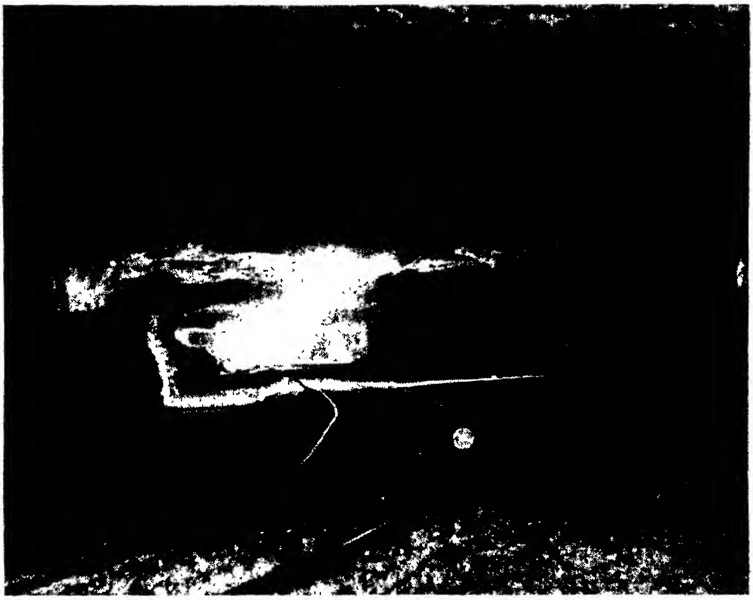


FIG. 7.—Main Haulageway, American Salt Corporation Mine, Lyons. Courtesy, Mr. H. H. Moseley, General Manager.

into one and half ton cars which are hauled on a 42 inch track by a battery driven locomotive to the shaft. Each car is then hauled up the shaft and to the plant for processing. An average room shot down in the manner described yields about 200 tons of salt per cut.[44]

All equipment in this mine is mechanized and derives its power from a source of electricity. Even miners' lamps worn on hats are battery operated.

In another Kansas mine, underground transportation in hauling

---

[44]Mr. H. H. Moseley, general manager of the American Salt Corporation recently wrote me (1946) that their salt mine at Lyons utilizes the ten foot strata of salt at the 1000 foot level. The room and pillar method of mining is also employed and involves removal of about ⅔ of the salt, the remaining ⅓ being left intact as support. Rock salt from this bed averages about 97.25% sodium chloride, the remaining 2.75% being blue shale and calcium sulfate.

The Evaporation and Mining of Salt, 6 pp., n.d., recently sent me by the Carey Salt Company of Hutchinson states (p. 2) that since their Hutchinson mine was opened in 1923, 209 rooms had been mined, each room being about 300 by 50 feet. Ceilings run from 7 to 10 feet in individual rooms and pillars of salt 20 feet thick are left between each room. At the end of each room a 50 foot wall of salt is also left intact. The space now mined out would be equivalent to a highway 50 feet wide and 25 miles long.

the mined rock salt is provided by mule power and the mine is reported to have one mule who has lived a contented underground life for twenty-two years and another who has not seen the light of day for nearly ten years.

FIG. 8.—Mine Cars Loaded With Salt Being Hauled to Shaft, Morton Salt Company Mine, Kanapolis. Courtesy, Mr. W. M. Veitch.

The depth of Kansas salt mines (depth of shaft) as reported to the writer are as follows:

TABLE 5.—*Depth of Kansas Salt Mines.*[45]

	Depth, ft.
American Salt Corporation, Lyons	1000.
Carey Salt Company, Lyons	1065.
Independent Salt Company, Kanopolis	850.
Carey Salt Company, Hutchinson	645.5
Morton Salt Company, Kanopolis	800.

Production of Salt by the Formation of Artificial Brines—Early in the history of salt production from the deep salt beds of Kansas, mining was done by water (hydraulic mining). Shortly after the discovery of the salt beds, the practice of drilling two holes close together until each reached salt was developed. The holes were cased and water was forced down one hole where it dissolved salt and the

[45]The data above has been supplied directly by each company. The bottom of the Carey mine at Hutchinson is 353.8 feet above sea level.

resulting brine was forced by the pressure of the descending water up the other hole.[46] Hydraulic mining, as will be apparent, has the advantage of purifying the salt by removing only that part of the salt beds which dissolve, but separation of the salt from the solution thus produced is necessary.

By the middle eighteen nineties, a somewhat different method of hydraulic mining was adopted.[47] At a Hutchinson plant, a six inch hole was drilled into the salt bed and cased. A smaller pipe two and a half inches in diameter was then inserted in the larger six-inch pipe but sunk to a greater depth and into the salt bed. Water was then forced down the small pipe and brine out of the larger pipe.

At Sterling, Kansas, where salt production was begun in 1889, the operation of the brine wells, as described in 1914, varied somewhat.[48]

An eight inch casing was put down to rock about 160 feet beneath the surface. A smaller pipe (5⅝ inch) was inserted in the larger one and put down 60 feet farther and was then cemented to rock. A third pipe of two inches and a half inch in diameter was then inserted in the 5⅝ inch pipe deep in the salt beds, the 2½ inch pipe and the 5⅝ inch pipe being tightly connected at the surface. Fresh water was then pumped into the smallest pipe under a pressure of 90 to 100 pounds and the brine forced up the 5⅝ inch pipe. Horner reports that in time the cavities formed by the solution of the salt became connected and it was then possible to pump water down one cavity and draw brine from the other. Cavities as far as a thousand feet apart could be used to produce brine.

With some modification, the general practice in producing artificial brine at the present time is essentially that of the processes described above. Concentric pipes are placed in a driven well. Water is forced down the outer pipe and brine rises through the smaller one (see Figure 9). If the well is deep, water pressure is not sufficient to raise the more dense brine to the surface and a small compressed air line with a U bend at the bottom is dropped down below the brine level, the air pressure and water pressure then being sufficient to raise the brine to the surface.[49]

---

[46]Dennis W. Cowan, *A History of the Salt Industry in Hutchinson, Kansas 1887-1940,* 71 pages, Master's thesis, Kansas State Teachers College, Pittsburg, Kansas, August, 1940, p. 27. The Cowan thesis is a valuable account of a part of the Kansas salt industry. It is based upon examination of the literature, upon examination of the office records of several of the Hutchinson salt processing firms, and upon interviews with workers and officers of several of the leading salt producing firms in Kansas.

[47]Cowan, *op. cit.*, p. 27.

[48]Robert M. Horner, *The Salt Industry at Sterling, Kansas,* Master's thesis, University of Kansas, 1914, 68 pp.

[49]Veitch, *loc. cit.*, p. 182.

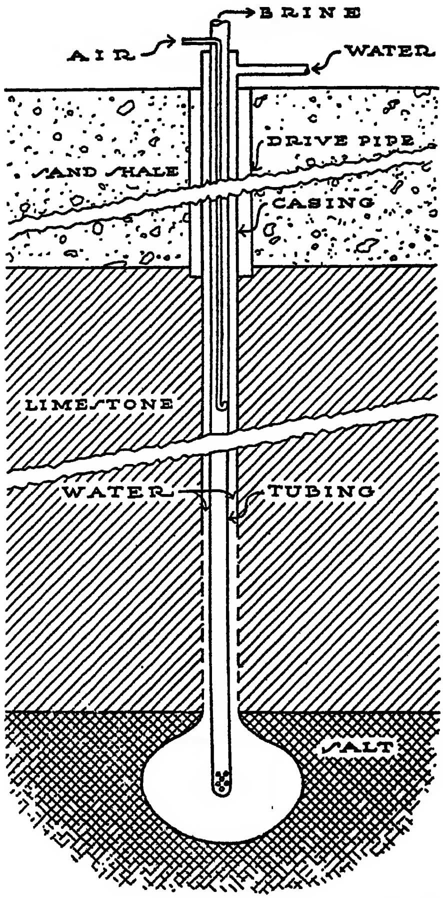


FIG. 9.—Salt Well, generalized diagram. Note the air line which aids in "boosting" the heavier-than-water brine to the surface. Courtesy, the Morton Salt Company, Chicago.

According to Cowan,[50] the brine produced by luke-warm water (which dissolves the salt more quickly than cold water) is over 99 per cent saturated. If the salt content drops belows 96% saturation, investigation is made to locate the source of trouble, which usually arises from the production of too large a cavity or by cave-in of the overlying formation above the salt bed. If the brine content drops as low as 90 per cent saturation and cannot be increased by readjusting the depth of the small inner pipe, the well is plugged and a new one drilled.

The life of a well may not be more than a year but some of

[50]Cowan, *op. cit.*, p. 28.

those at Hutchinson have a reported average life of fourteen years. Cave-ins at the bottom of the well which may occur as frequently as twice a year, necessitate the difficult and expensive operation of re-drilling the well hole through loose rock and pumping out the mud which blankets the bottom of the salt bed.[51] The wells in use at Hutchinson are reported to utilize salt beds at an approximate depth below the surface of 780 feet.

Trump[52] has within recent years described a further modification of securing artificial brines. Although a detailed description of the Trump method is not needed here, it can be pointed out that it consists in forcing *both* air and water to the salt bed where the air expands in the cavity that forms as the salt is dissolved (see Figure 1 or 9). The compressed air rising to the surface of the solution in the cavity, forces the water away from the roof toward the lower part of the bed thus preventing solution of the salt above and delaying cave-ins. The debris from the cave-in settles to the bottom of the well and forms a coating over the salt thus preventing or slowing up its solution by water. The prevention of cave-ins and the formation of the subsequent blanket of insoluble material on the bottom, results, it is claimed by the Trump method, from a horizontal undercut or cavity in the salt bed and not the pear-shaped cavity that is ordinarily formed. As far as the writer knows, however, the Trump method is not now employed in any of the Kansas mines. In 1936, Trump estimated that a completed salt well by his method would cost about $10.00 a foot. Thomas, however, reports that in 1941 the cost of a brine well completely installed at Hutchinson, by the method now in use, was approximately $12,000. for a 800 foot well.[53]

Evaporation and Purification of Brines.—Three principal methods are used in securing salt by the evaporation of artificial brines: the grainer process; the vacuum pan process; and the Alberger process. The first process produces flat flakes of salt and is known as "flake salt" or "grainer salt" which is used in large quantities in making cheese, butter and by bakers in the production of bread and in the dry salting of meats. Salt produced by the vacuum process forms minute cubes (the natural crystal form of salt) of high purity with greater efficiency than any other process. Table salt is produced by this process. In the Alberger process, salt crystals of many sizes and shapes are produced but the salt is of great purity (99.95%

---

[51]Cowan, *loc. cit.*, p. 28; Thomas (see note 108), p. 21.

[52]Edward N. Trump "Increasing Brine Output From Salt Beds", *Chemical and Metallurgical Engineering* v. 43, pp. 364-365 (1936); "Mining Soluble Salines by Wells", *Technical Publication*, No. 1733, American Institute of Mining and Metallurgical Engineers, 1944; U. S. Patents No. 2,009,534, July 30, 1935 and No. 2,009,535, same date.

[53]Thomas (see note 108), p. 31.

NaCl) but it is the least economical method for the production of a given quantity of salt.[54]

The grainer and vacuum processes are the most used in Kansas and the details of these two methods will be outlined briefly.

FIG. 10.—Grainer Room and Pans. The salt may be seen crystallizing on the surface of the brine in the pan nearest the observer. Courtesy, The Carey Salt Company, Hutchinson.

In the grainer process, the brine as pumped from the well goes first to settling tanks to remove suspended and insoluble materials (anhydrite, clay, sand, etc.). When clear, the brine is drawn into another tank (or series of tanks) which is heated with submerged steam coils and treated with lime and soda ash which precipitates (removes) most of the calcium and magnesium salts dissolved in the brine.* After this precipitated material has settled, the clear brine flows into long, narrow and relatively shallow troughs which contain pipes through which steam is passed; the brine is heated by the hot pipes and water from the brine is evaporated. These troughs, called grainer pans, are of various dimensions. One company uses pans 150 feet long by 18 feet wide and 1½ feet deep; another com-

[54] James A. Lee, "A Salt for Every Purpose." *Chemical and Metallurgical Engineering*, v. 47, pp. 530-534 (1940). The three processes mentioned above are described in some detail for a plant which uses all three methods, the Diamond Crystal Salt Co., St. Clair, Mich.

*Not all companies, however, purify their brine by the lime and soda ash treatment.

pany uses grainer pans 90 to 120 feet long, 15 feet wide and 2 feet deep; still another, 125 feet long, 10 to 12 feet wide and 3 feet deep.[55] The main feature of the grainer pans is that they are long, narrow, and shallow. A battery of grainer pans is located in a room provided with extensive ventilating facilities to remove the steam formed upon evaporation. The temperature of each bath is kept at a constant and desired value as the variation of even a few degrees will produce differences in the size of the salt grain. When sufficient water is evaporated from the brine, salt begins crystallizing out on the surface of the brine, for, since evaporation is taking place from the surface, the salt solution will reach its greatest concentration there. The initial salt crystals serve as centers for increasing crystallization of the salt and the solid salt therefore grows flat along the surface and hence the "flakes" of salt, previously mentioned, are produced. Finally the flakes become so large and heavy that they sink in the brine. Automatic scrapers move along the bottom of the pans and continually remove the settled flakes to drain boards at the end of the grainers, where it is gathered up by mechanical conveyors (continuous belt) and taken to driers. Where the brine does not receive the chemical pre-treatment described above, the crystals recovered from the grainers are washed with incoming—and therefore more dilute—brine. The adhering brine from the grainer, which, because of evaporation, has become richer in calcium and magnesium chlorides, is thereby removed. Calcium sulfate, also, which precipitates as very fine adhering grains can be removed to a large extent by the washing process.

The salt leaving the grainers is eventually dried by the use of filters and by forcing hot air through the salt mass or by heating it in rotary driers. Finally the salt is screened to obtain various size flakes.[56] As the salt continually crystallizes, the remaining brine becomes richer in magnesium and calcium. Further, calcium sulfate tends to coat on the steam pipes and as a result of these processes, the grainer troughs have to be cleaned and scaled at regular intervals. It should be noted that since surface or well waters are used for the preparation of the artificial brine any dissolved material in

---

[55]Lee, *loc. cit.*, p. 531; Veitch, *loc. cit.*, p. 198; Cowan, *op. cit.*, p. 32.

[56]The description of the grainer process and the vacuum process which follows in the text is taken from Lee and from Cowan (notes 46 and 54), from the *History of Salt* published by the Morton Salt Company, 32 pages (no date, but probably published sometime during the 1940's). An extensive monograph W. C. Phalen *Technology of Salt Making in the United States*, Washington, 1917, (Bulletin 146 of the U. S. Bureau of Mines) 149 pages, gives a fairly complete account of the methods in use at the time of publication. For the early technology of salt in Kansas, see Robert Hay, *Mineral Resources of the United States* 1888, Washington, 1890, p. 608; Bailey, "Salt in Kansas," *loc. cit.*, pp. 167-180; and M. Z. Kirk "Technology of Salt," *Mineral Resources of Kansas*, 1898, Lawrence 1899, pp. 98-123.

the original water will appear also in the final brine and water of as high a purity as is economically possible is therefore used.

Vacuum Pan Salt.—In this process, the clarified, and usually purified, brine is heated under reduced pressure in huge evaporators called vacuum pans. Such pans are used in batteries of three or more each under a successively lower pressure, a practice that materially reduces fuel cost in evaporation and makes this process a practical one. The initial cost of the vacuum pans is high as they are large and complex pieces of apparatus (see Figure 11). Each pan, or evaporator, consists of two large metal cones set base to base, but with a large doughnut shaped section between the cones. The "doughnut" section, or the steam belt, extends far into the evaporator on all sides but an open well is left in the center of the belt. Through the steam belt are run many thousands of vertical copper tubes, open at both ends to the interior of the evaporator. These tubes may be as much as five feet in length but are of small diameter. Brine is forced upward through these copper tubes and steam is led into the steam belt around them. If now the pressure in the evaporator proper (above the brine) is reduced so that the brine boils at 150° F., rapid evaporation of the water from the brine will take place and salt will crystallize out, the crystalline sludge then being carried down through the center well by a propeller (see cut away portions of the second and third evaporators in Figure 11 where the vertical tubes in the steam belt and the propeller below the well are shown). The steam from the first evaporator is then conducted to the steam belt of the second evaporator where the brine is under a still lower pressure; sufficiently low that the brine boils at a lower temperature than in the first evaporator. Lastly the steam from the boiling brine in the second evaporator is lead to the steam belt of the last evaporator which operates under a still lower pressure. The only heat required, therefore, for all evaporators is that required to heat the steam in the first one and to power the pressure reducing devices used in all three evaporators.

The salt as it crystallizes out sinks, and is drawn out at the bottom of the evaporator along with considerable brine. The sludge of salt and brine is then led to a filter to free it of most of the brine. The salt is then aged and dried and is ready for packaging.

The evaporators are run for several days and then boiled out to remove salt clinging to the walls and to remove some scaling which occurs in the copper tubes, although, strangely enough, the salt shows no tendency to cling to the walls of the small copper

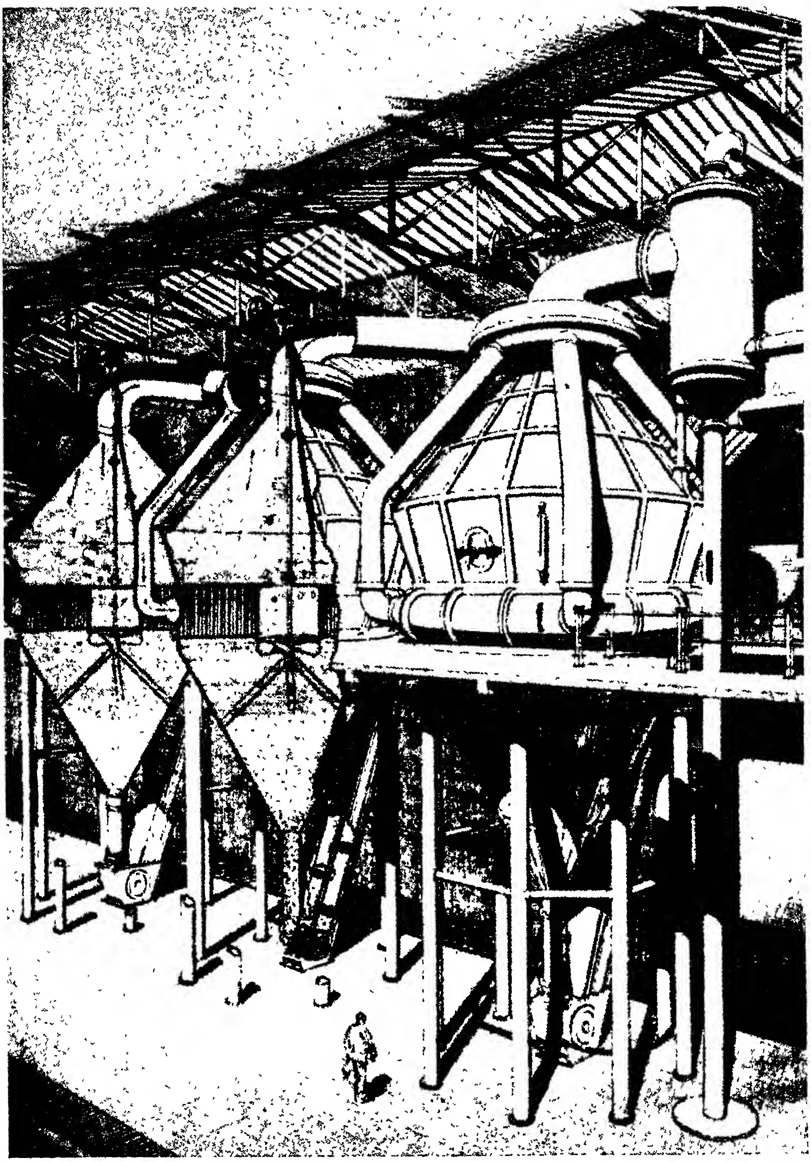
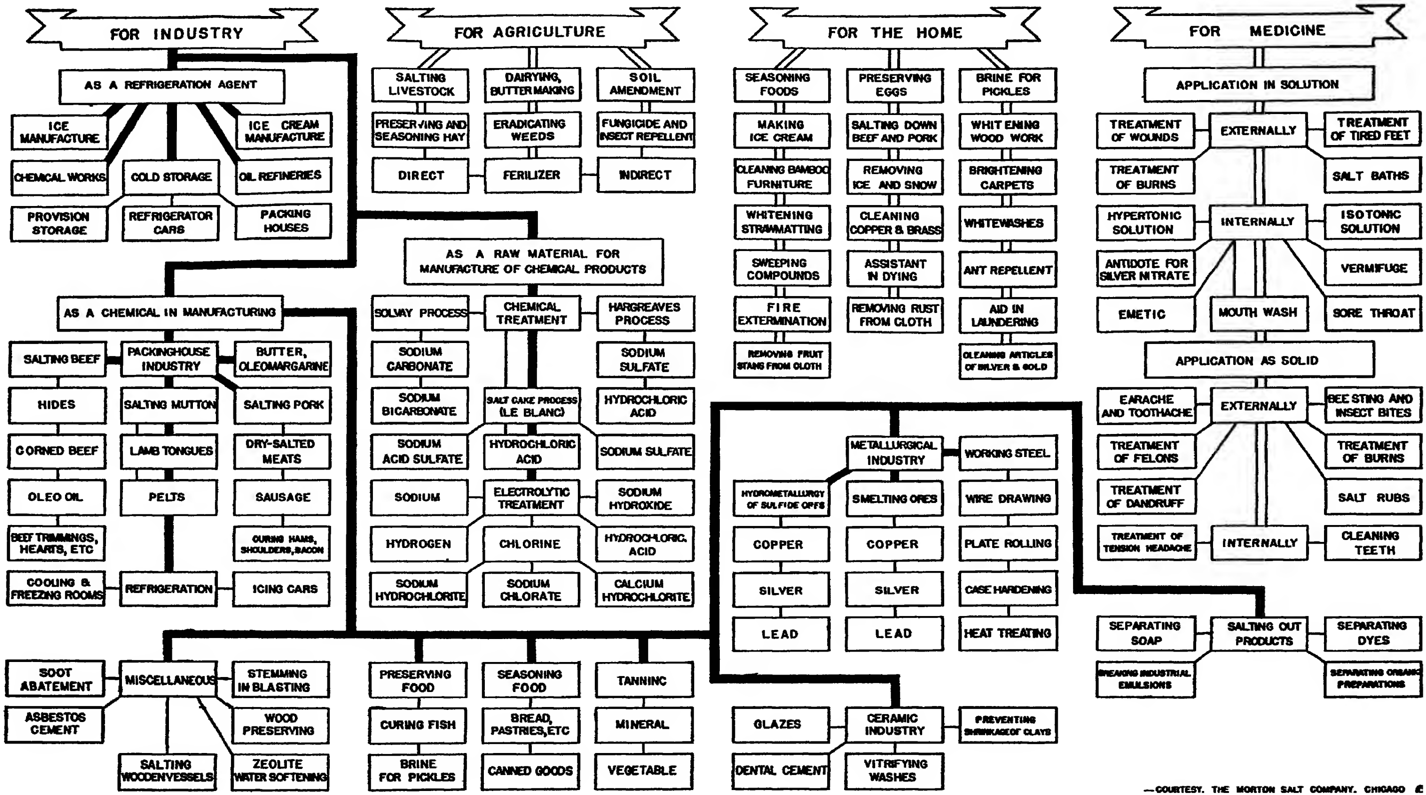


FIG. 11.—A Battery of Vacuum Pans. The small figure of the man in the foreground shows the scale on which the "pans" are constructed. The second and third pans are given in cross section to show the vertical copper tubes in the steam belt, and the propeller at the base of the well in the belt. Courtesy, the Morton Salt Company, Chicago.

— USES OF SALT —



—COURTESY, THE MORTON SALT COMPANY, CHICAGO

tubes. The scale, however, if the brine has originally been made slightly alkaline with lime, consists chiefly of basic magnesium carbonate which is largely removed in the boiling out process.

Uses of Salt

It would be difficult, if not impossible to list all the uses of salt and, for our purpose, unnecessary. The diagram shown in Figure 12 suggests some 1400 uses of this common, but important, mineral, and doubtless the number could be increased to over 2000 uses if all were considered. It finds use not only in its compound form, that is as sodium chloride, but subjected to chemical treatment, it can be separated into its elements, sodium and chlorine, which are either used in their elementary state or which can be converted into other compounds of sodium and of chlorine. The following table gives some idea of the main uses of salt and the amounts used in short tons, for the year 1945 in the United States.

TABLE 6.—*Principal Uses of Salt, 1945, Short Tons.*[57]

Use	Evaporated Salt	Rock Salt	Brine
Chlorine, bleaches, chlorates, etc.	795,859	644,916	1,092,200
Soda ash	slight	none	7,087,227
Dyes and organic chemicals	58,101	41,460	none
Soap (precipitant)	50,141	18,862	slight
Other chemicals	105,363	441,579	slight
Textile processing	35,968	101,378	none
Hides and leather	105,227	161,049	none
Meat packing	362,202	360,744	none
Fish curing	36,123	71,571	none
Butter, cheese and other dairy products	112,087	5,592	none
Canning and preserving	156,713	16,164	none
Other food processing	230,993	22,243	none
Refrigeration	45,449	235,904	none
Livestock	539,929	192,817	none
Highways, railroads, dust and ice control	10,149	307,656	none
Table and other household uses	472,106	210,175	none
Water treatment	179,554	196,842	slight
Agriculture	42,753	14,013	none
Metallurgy	28,922	29,000	slight
Other uses	263,100	433,775	78,245
Totals	3,630,729	3,505,740	8,257,672

According to the above table, the total salt used in this country in 1945 was some fifteen million tons (the sum of the three totals above) and nearly half of this quantity was used in one industry, that of producing soda ash (sodium carbonate). Further, over half the total salt used was consumed in industries that used brine directly, i.e., without recovering salt from natural or artificial brine.

Soda ash finds its principal uses in the manufacture of glass, of caustic soda (sodium hydroxide), of sodium bicarbonate and in the production of numerous other chemicals. Chlorine, the second greatest of the products produced from salt finds its use chiefly in the chemical and paper industries.[58]

---

[57]Harris and Tucker, *Salt, op. cit.*, p. 7.

[58]*Chem. and Met. Eng.* v. 52, p. 129 (Feb., 1945) where data will be found on both soda ash and chlorine.

To illustrate, however, the far-reaching and varied influence which salt has upon our present life, it can be pointed out that about half the table salt now produced in this country is iodized. That is, traces of iodides are added to salt. This procedure, begun in Michigan in 1924, has resulted in the practical disappearance of goiter in Michigan and Ohio, a region where the incidence of this pathological condition was once abnormally high.[59]

Of particular interest to Kansans is the consumption of salt in the meat packing and livestock growing industries, as it is probable that little of Kansas salt goes into the making of soda ash or of chlorine, the two processes that consume so large a share of the salt production in this country.[60]

Zerger, however, has suggested on the basis of available data that Kansas, which has a very large per capita consumption of evaporated and rock salt (175 pounds per person in 1939 as against 74 pounds per person in New York State), owes its high consumption of salt to the development of the meat packing industry which produces over five per cent of the nation's total meat packing products.[61] Zerger, however, makes no attempt to estimate the consumption of salt in the livestock industry of the state, which undoubtedly utilizes an appreciable fraction of the annual production of salt.[62]

In this connection, the following data supplied by one of the leading producers of salt in Kansas, is of more than passing interest.[63] The date is that of 1939, probably the last year of normal production before World War II began to change our economy.

TABLE 7.—*Uses of Kansas Salt (Single Producer).*

Use	Per cent of total production
Table use and kitchen use	6%
Meat packers	12%
Farm uses	63%
Ice cream manufacturers	4%
Miscellaneous industrial uses*	15%

*Includes use in self-rising flour, creamery butter, cheese, fertilizers, dyes, ice manufacturers, water softeners, canning, baking, paper manufacturers, railroads, etc.

It should be observed that the proportions of production going to various uses indicated above were not those confined to Kansas alone, for the company in question exported most of its total pro-

---

[59]*Minerals Yearbook,* 1943, p. 1532; *Science,* v. 85, March 19, 1937, Supplement, p. 12.

[60]There are no data available to the public that would give information on the ultimate destination of all Kansas salt.

[61]Carl R. Zerger, *Historical Notes on Kansas Salt,* 175 pp. Master's thesis, University of Kansas, August, 1945, Chapter X, "Salt Consumption in Kansas."

[62]Farm families, for example, spend fifteen dollars for salt for every dollar spent by a town family according to the Carey Salt Company (see *Printers Ink,* v. 189, Nov. 24, 1939, p. 17). Undoubtedly an appreciable proportion of the average farm family's supply of salt doubtless goes into home curing of meats but a considerable proportion must go into livestock feeding.

[63]Letter to the writer, Dec., 1939.

duction (95% exported, only 5% used within the state). Conditions are undoubtedly somewhat different at present and the proportion must vary considerably from company to company.

That World War II considerably increased the total salt production is shown by an examination of Fig. 13. As can be seen the total production (better, the total salt sold or used by producers) of salt began its upward climb in 1939, increased most rapidly in 1941 and reached its maximum value in 1944 (15,717,000 short tons).[64] Although the rise in salt production does not equal industrial production and maximum salt output was reached the year after the peak

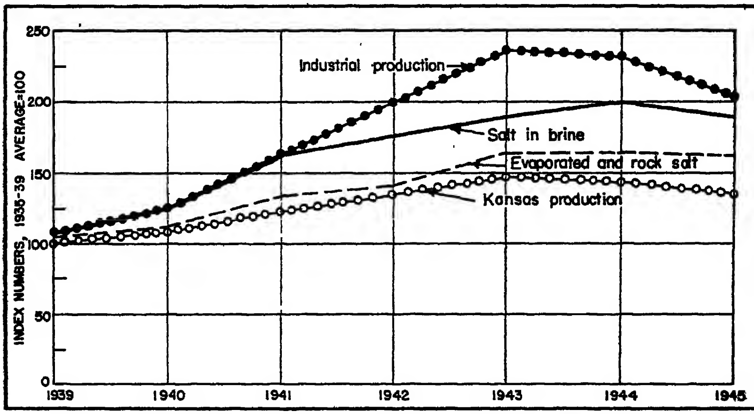


FIG. 13.—Relative Changes in Salt Production During the War Years Compared to Industrial Production. The index of 100 is based on the 1935-39 average. The Kansas production includes both rock and evaporated salt. The three upper curves refer, of course, to total production in the United States. After Harris and Tucker, 1945.

industrial production, the total salt produced in 1944 was over 80 per cent greater (nearly double) than the five year average of 1935-1939 inclusive. The greatly increased output was not the result of increases in plant facilities in the east and middle west but came largely from increased production in already existing plants.[65]

The increases in production during the war were absorbed chiefly in the soda ash and chlorine industries but some new and interesting uses were also developed.

The increased demand for soda ash arose at the beginning of the war from the greatly increased use of glass to replace metal in food containers and other metal devices; the increased use of

[64]Although Figure 13 shows salt production in brine and in evaporated and rock salt, calculation of *total* salt from the *Mineral Yearbook* for 1940-1945 inclusive would give a curve lying between the two salt curves of Figure 13 but nearer "salt in brine" because of the larger proportion of salt produced in this manner.

[65]F. E. Harris and E. M. Tucker, *Salt*, *op. cit.*, p. 2. On the Pacific, plant facilities for solar salt production (evaporation by sun) were considerably increased during the war.

chlorine (it takes 3,000 pounds of salt to make 2,000 pounds of chlorine) arose from the increased use of chlorine in making chemicals and munitions of war including high octane gasoline, not only for our own use, but to supply lend-lease requirements.

Among the interesting new uses developed was a demand for salt in the production of DDT and of synthetic rubber. In the latter case, salt consumed, exclusive of that used for making chlorine, also necessary in rubber manufacture, rose from 66,000 tons in 1943 to 200,000 tons in 1945. Demand for salt as a fertilizer which has been of periodic interest for many years rose somewhat during the war. Improved eating and keeping qualities of celery, for example, were reported in 1941 from experiments carried on with salt as a component of fertilizers for certain types of soils.[66]

In concluding this brief review of the past uses of salt it may be pointed out that in 1939, the last "normal" year, 94,603 tons of salt, valued at $1,860,000, were used in the manufacture of bread, biscuits, crackers and pretzels alone. As the writer remembers the pretzel, salt used per pretzel probably exceeded salt per unit in any of the three other types of the food products listed above.

As for the future uses of salt, the *Minerals Yearbook*, 1944, (p. 1494) states:

> During World War I, great advances were made in the chemical industry in the United States, and additional gains have been made in World War II. During the interwar period the chemical industry never lost the foothold it had obtained in the First World War, and the salt output used for chemical manufacture gained and did not fall below that of prewar years, except for one year: in 1921 it was less than in 1913 and 1914. During the interwar years the United States led in world production of chemicals. There is every reason to believe that, in the coming period, although some lines of business may recede the chemical industry will retain a great part of its wartime gains, and consumption of salt—one of the most important chemical raw materials—will likewise be maintained at a high level.

History and Statistics of the Kansas Salt Industry

That the occurrence of salt in Kansas has been long known is evident from such geographic names as the Saline River, Saline County, Salina, Salt Creek (of which there are at least 12 in the state). Although these names were bestowed at a comparatively late date, their use indicates that salt was known in Kansas before written history of the country was begun. Salt springs and marshes and so-called salt "licks" were used by our red predecessors and by animals of the Plains and the occurrence of these natural phenomena was noted by early explorers. The famous Zebulon Pike in 1806

[66]These brief uses of salt in war-time are based on the *Minerals Yearbook* for the period 1940-45 inclusive.

FIG. 14.—Salt is marketed in many ways; rock salt crushed to various sizes; table salt in granulated form; and salt blocks in various sizes and shapes. In the photograph above, salt blocks are made in 20 seconds by subjecting salt to an approximate pressure of six tons per square inch. No binder is necessary to hold the salt together in the block. Courtesy, The Carey Salt Company, Hutchinson.

observed on the record of his western expedition on September 18 of that year "marched at our usual hour, and at twelve o'clock halted at a large branch [Saline River] of the Kansas [Smoky Hill] which was strongly impregnated with salt."[67]

In 1830, Isaac McCoy, the well-known missionary and government surveyor of Indian reservations in Kansas, mentioned deposits of salt seen on the banks of the Solomon River (and some of its tributaries) when some 200 miles west of the Missouri line. McCoy also mentioned—and in 1840 described—a salt spring of renown in the same vicinity, Waconda, or the Great Spirit, spring.[68] The salt

[67]Elliott Coues, ed., *The Expeditions of Zebulon Montgomery Pike*, New York, 1895, v. 2, p. 405; Theo. H. Scheffer "Geographical Names in Ottawa County" *Kansas Historical Quarterly*, vol. 3, p. 231, 1934.

[68]Lela Barnes, "Journal of Isaac McCoy for the Exploring Expedition of 1830," *Kansas Historical Quarterly*, v. 5, p. 373 (1936).

flats south a few miles of the present Oklahoma-Kansas border were also early known and the surface salt deposits used locally to some extent in early days.[69]

In fact, salt springs and marshes and their potential use were so well-known by the time that Kansas was organized as a state in 1861 that the act under which Kansas was admitted to the Union provided (in part):

> Section 3. *And be it further enacted,* . . . That all salt springs within said State, not exceeding twelve in number, with six sections of land adjoining or as contiguous as may be to each, shall be granted to said state for its use, the same to be selected by the Governor thereof within one year after the admission of said State. . . .[70]

The salt springs (marshes were actually selected) were designated by Governor Robinson and were subsequently alloted to the State Normal School at Emporia (now Kansas State Teachers College) as part of the school's endowment.[71]

Very probably all salt springs and marshes—including these belonging to the state—in early Kansas were used by early settlers in the vicinity as a source of supply for their own needs. Commercial production of salt in the state, despite the considerable evidence that salt was available, seems to have been almost completely lacking in the state. The state legislature of 1863 to encourage salt production even offered a bounty of ten cents per bushel on salt produced in the state, provided that not less than 500 bushels of salt were manufactured.[72] The bounty was good up to 10,000 bushels but apparently no one applied for the bounty.[73]

J. G. Tuthill of Republic County, has previously been regarded as the pioneer commercial manufacturer of salt in the state but the writer, on the basis of evidence given later, is inclined to give the honor to the Osawatomie Salt Works, owned by William Chestnut and others. These salt works were in production by 1863 (and possibly earlier), the salt being secured by the evaporation of brine from five salt wells which had been drilled to depths of 136, 270, 86, 120 and 115 feet respectively.[74] Analyses of the brine and of the salt found at Osawatomie had been made by Dr. C. T. Jackson, state assayer of

[69]Nyle H. Miller, "Surveying the Southern Boundary Line of Kansas" (From the Private Journal of Col. Joseph E. Johnson), *Kansas Historical Quarterly*, v. 1, pp. 118-120, 1931-32; Martha B. Caldwell "The Southern Kansas Boundary Survey," *Kansas Historical Quarterly*, v. 6, p. 360, 1937.

[70]*United States Statutes at Large*, (Boston, 1865), v. XII, p. 127.

[71]Zerger, *op. cit.*, Chap. V, discusses the transactions involving the state salt springs in some detail. The more important of these marshes were located in present north-central Kansas and in south-central Kansas. Robert Hay, *Seventh Biennial Report of the Kansas State Board of Agriculture* (Topeka, 1891), Part II, pp. 87-92, describes and locates a number of these marshes and in the *Eighth Biennial Report of the Kansas State Board of Agriculture* (Topeka, 1983), Part II, p. 139, makes a list of them, some 12 in number.

[72]*Laws of the State of Kansas*, 1863, pp. 88-9, cited by Zerger, *op. cit.*, p. 59.

[73]Zerger, *op. cit.*, p. 59; see also, note 76.

[74]G. C. Swallow, *Preliminary Report of the Geological Survey of Kansas*, Lawrence, 1866, p. 84.

Massachusetts, as early as June, 1862,[75] and showed that the brine was unusually strong and that the evaporated residue from the brine contained about 98 per cent salt. A description of the salt works at Osawatomie made in November, 1863, stated that 17 kettles each having a capacity of 30 gallons were set in a single furnace to evaporate the salt, which sold locally for $1.40 a bushel.[76] Apparently, however, this plant did not operate continuously.[77]

In the spring of 1866, according to the Andreas-Cutler history of Kansas, Mr. J. G. Tuthill located a homestead on the east side of an extensive salt marsh in southeast Republic County, Kansas.[78] The marsh was already well-known before Tuthill's arrival and had been previously explored by Professor B. F. Mudge, the first state geologist. Mudge secured samples of the brine from the marsh and submitted them for analysis to Professor C. F. Chandler, the well-known chemist of Columbia University.[79] Mudge published the results of the analysis in his first report (see note 75) but before publication in his report, a Kansas correspondent of the New York *Tribune* had written a lengthy description of salt possibilities, including the analysis of the salt obtained from the marsh in Republic County. The account is so odd a mixture of science and optimism and reveals so much of the atmosphere of the time in which it was written that it is reprinted here in whole—and without change of spelling.

WYANDOTE, Kansas, Nov. 4, 1865

Besides the great capabilities of Kansas for agricultural purposes, stock-raising and wool-growing, there is yet another source of wealth, in relation to which but little is known, within as well as out of the State. I refer to the Salt Springs, which exist above Fort Riley, in the valleys of the Republican, Solomon and Saline Forks. So abundant are these surface brines, and of such uncommon strength, as sensibly to effect the quality of the large streams of water which run through those valleys and empty their transparent volumes into the Smoky Hill. In fact, during the period of protracted drouth, the waters of the Solomon and Saline become so brackish as to unfit them entirely for domestic purposes. These salines, however, are of great benefit to the stock-raiser, as his flocks and herds require no salting, as in the Eastern States.

This saline region, and which may be called in verity the Kansas Salt

---

[75] B. F. Mudge, *First Annual Report* [for the year 1864] *on the Geology of Kansas*, Lawrence, 1866, p. 47. Mudge also reported (pp. 32 and 33) that salt wells or springs were known in the neighborhood of Mound City, Marmaton and Emporia and that in Brown County, the Leavenworth Salt and Coal Oil Company had a "promising" open well containing a salt spring yielding brine of enough strength to warrant production of salt.

Swallow, *op. cit.*, p. 61, repeats essentially the above observation but the only salt works mentioned are those at Osawatomie. Other possible salt sources are mentioned in Swallow on pp. 102, 111, and 113.

[76] "The Osawatomie Salt Works," *The Kansas Farmer*, v. 1, Nov. 1, 1863, pp. 153-154. A bushel of salt is 56 pounds. *The Kansas Farmer* account states that active production began at Osawatomie in April, 1863, the venture having been started as a result of the salt bounty law enacted by the Kansas legislature of 1863, mentioned above in the text.

[77] Swallow, *op. cit.*, p. 85.

[78] Andreas-Cutler, *History of the State of Kansas*, Chicago, 1883, p. 1032.

[79] Mudge, *op. cit.*, p. 34 and 47.

Group—as the salines of the Saginaw Valley are denominated the "Michigan Salt Group"—and those of New York, the "Onondaga Salt Group"—have their center, quite probably, near the confluence of the Solomon and Smoky Hill. This fact, however, can be determined only by sufficient borings.

While the strength of the brines in this section have not as yet been tested from wells beyond the influence of fresh water, there is little doubt, however, as to their great strength and purity at a limited depth below the surface. This is evident not only from the geological features of the country, but from the great strength of the surface brines, and also from the incrustations of pure salt on the top of the ground, covering hundreds of acres, from three-eighths to half an inch in thickness. These remarkable formations come from brine oozing up from below, and not from surface flowings. The whole subsoil seems thoroughly impregnated with a constant upward tendency, so that crystalization succeeds crystalization on the removal of the salt already formed. This fact alone seems to be very conclusive proof of the above supposition. There is yet another, however, of a more practical, and, perhaps, conclusive character. An individual residing near to one of these salt deposits, or marshes, as they are called, without any of the peculiar features of a marsh, however—has succeeded in sinking an ordinary well in the formation near him to the depth of some 25 or 30 feet, and from which he is obtaining brine of such strength that 107 gallons will make a bushel of salt. While this brine is more than three times the strength of sea water, yet it is nowise superior to several flowing springs in this salt region. If, however in this particular locality a brine is obtained some 30 feet from the surface, 107 gallons of which are sufficient to make a bushel of salt, what, indeed, is its strength at the depth of 100 feet? Is it not safe to conclude that at this latter depth a brine exists at or near the saturation point?

The East Saginaw Salt Manufacturing Company of Michigan in sinking its well in 1860—and which has subsequently proved so remarkably successful—at the depth of 90 feet obtained brine of only one degree in strength, and at the depth of some 500 feet, brine in no respect stronger than the Kansas brine from the above marsh at 25 or 30 feet.

The great purity of the salt made from the brines of this section is another important characteristic. The only chemical analysis of Kansas salt as yet made, so far as my knowledge extends, is from a sample placed in the hands of C. F. Chandler, Professor of Chemistry, &c., of Columbia College in July last. This sample was obtained by solar evaporation without any particular care, however, and in the most primitive mode imaginable—a trough from a cotton-wood log being the only kind of vat used, and in which it remained until the process of crystallization was fully completed.

A committee from the New York Legislature, which visited and investigated the Michigan Salt Group in 1862, in making its report observe: "It is only by chemical analysis that the value of brine can be determined. All the brines used in the manufacture of salt this side of the Mississippi River, with one exception, that of Saltville, in South Western Virginia, are loaded with impurities, which must be removed or the salt is valueless." In view of this vast superiority of the brines of the Kansas Salt Group, as determined by the chemical analysis of Professor Chandler, and which is given below is seen at once:

ANALYSIS

	(100 parts)
Cloride of Sodium (salt)	96.689
Sulphate of Soda	1.959
Sulphate of Lime	0.216
Chloride of Magnesium	0.300
Sand and Clay	0.050
Water	0.786
	100.000

This analysis shows a most remarkable degree of purity under any circumstances whatever; and when it was considered that no attempt was

made in the manufacture of the sample to purify the brine, is, perhaps, unprecedented, and shows a saline in all respects equal to that of Saltville, Virginia, if not, indeed, superior.

It will be noticed that chloride of calcium (the deleterious bitter waters of the salt manufacturer) is not a component of this Kansas salt, and not even a trace of iron. In all the assays which I have met with of Onodaga salt, chloride of calcium and iron are two of its components. The best description of Saginaw salt contains also a large amount of the former injurious substance, and it is only by an expensive chemical process that these and other impurities are removed; and hence, it is seen that salt from the Kansas Group, without resort to any chemical process whatever in its manufacture, is equal, if not indeed superior, to any in the United States under all circumstances whatever.

In connection with this brief notice of the salines of Kansas, there is one fact of so much practical importance, in view of the working of these brines at some day, that I will revert to it before closing. It is now an admitted fact that the cheapest mode of salt-making is by solar evaporation, and that the article so made is greatly superior to that procured by artificial heat. If this is the case in Michigan, New York, &c., how much more so in Kansas, with its pure, dry atmosphere, and large number of clear, hot days. According to Blodgett's Climatology, a standard American work, the amount of rain and snow annually falling at Fort Riley—and which lessens further West—is 21.90 inches, while at Utica, New York, it is 40.57 inches. At the Onandaga salt works there are annually 128 rainy days, and but 62 good days for salt-making by atmospheric evaporation, while at Fort Riley there are but 68 rainy days and about all the balance of 365 good days, it is believed, for salt-making.

In addition to these important particulars on the side of Kansas for the manufacture of salt, there is yet another in the brisk atmospheric currents which sweep over the State at all seasons of the year, and which are great promoters of rapid evaporation. Every stranger visiting Kansas is struck with this fact by the short time necessary to change muddy, impassable roads to dry and good ones. Hence, from these facts, the conclusion is irresistible that more than double the quantity of salt can be made in Kansas from mines of the same relative strength, in a given space of time, than at any point east or south.

H.[80]

Salt obtained by the clarification and evaporation of brines from the Tuthill Marsh was sold in the nearby town of Seapo during the 70's and may have been sold in towns farther east.[81] It is possible, however, that the letter reproduced above led to the first important commercial production of salt in the state; that at Solomon City.

[80] New York *Daily Tribune,* Feb. 17, 1866, p. 4, c. 2. Although the above letter does not identify the source of the salt as the Tuthill marsh, the Mudge report of 1864 (see note 75) p. 47, mentions the marsh by name and reports exactly the same analysis as given in the letter above and also mentions Chandler, the analyst. My colleague, Dr. W. H. Schoewe, suggests that "H", the signer of the letter above was Major F. Hawn, in the early sixties, assistant state geologist and in territorial days, a member of several geographic surveys. Hawn, incidentally, was a charter member of the Kansas Academy of Science; see these *Transactions,* v. 47, p. 122, 1944-45.

[81] Kirk, "Kansas Salt", *loc. cit.,* p. 73. Kirk states that Tuthill marketed salt in Manhattan "in the early sixties". If the Andreas-Cutler account is correct (see note 78), Tuthill did not reach Republic County until 1866. Mudge, *op. cit.,* p. 34, speaks of harvesting salt at this marsh "for the past three years." Although Mudge's report is for the year 1864, it was not published until 1866 and there is evidence that the report was either written or revised just before publication (see p. 9 of the Mudge report, which mentions events *after* September, 1865). These facts would make it appear that the Tuthill marsh was known for its salt production as early as 1863, but not necessarily operated by Tuthill. The salt works at the Tuthill Marsh are mentioned in the *Third Annual Report of the State Board of Agriculture,* Topeka, 1874, p. 193. Robert Hay visited the Tuthill Marsh in 1890, 25 years after Mudge's visit, and found it greatly reduced in size and its brine strength considerably lower (*Seventh Biennial Report Kansas State Board of Agriculture,* Topeka, 1891, Part II, p. 88.)

Published in the widely distributed *Tribune,* the account of salt possibilities in Kansas may have suggested to interested New Bedford, Massachusetts, individuals a venture in Kansas salt. At any rate, in 1866 or 1867, a well was drilled near a salt spring some two miles west of Solomon City by the Massachusetts outfit.[82] A visitor to this salt plant in 1869 gives some contemporary details for he writes:

> Solomon City, Oct. 14 [1869]—Visit salt works 2 miles west of S. C. Well 600 feet. Wind mill, thirty vats of 1,000 ft. Salt pure white, but large globules or cubes, ground by steam, 4 to 5,000 bushels on hand. Capital $25,000, owned by Co. at New Bedford, Mass.[83]

As this account shows, salt was obtained from a brine well and was evaporated (by sun) to secure the salt. By 1881, the salt works had undergone a change in ownership and had been enlarged, and were then producing about 10,000 barrels of salt a year which supplied the local demand but the greater portion was shipped to the mining regions of Colorado.[84]

The Solomon City plant was in operation as late as 1898 for reports on its production and a photograph of the plant appears in Kirk's report of that year.[85]

The continued production of salt at Solomon City as late as 1898 is remarkable in that the major salt development in the state had taken place eleven years before this date.

Discovery of rock salt.—In the middle eighties, central Kansas was undergoing a very considerable expansion: real estate development, land speculation, formation of public utilities companies and greatly increased immigration were all under way. These phenomena were, by no means, confined to central Kansas but were taking place all through the West but the result of all these activities had a special significance in this area as far as salt in Kansas goes.

Among the speculative enterprises in this region were companies organized to drill for gas, oil and mineral products and by the

---

[82] Andreas-Cutler, *op. cit.*, p. 691, gives the date as 1866 and the name of the producer as the Continental Salt Co. Kirk, "Kansas Salt", *loc. cit.*, p. 76, gives the date of drilling as 1867 and identifies Wm. Taylor of New Bedford, Mass., as the promoter of the Continental Salt Company. Kirk gives considerable subsequent history of salt production at Solomon City as does Andreas-Cutler. C. C. Hutchinson, *Resources of Kansas*, Topeka, 1871, p. 84, states that the brine well was 600 feet in depth at Solomon City and that by solar evaporation, salt had been manufactured for three years; which would give the date of the beginning of the enterprise as 1867 or 1868. Brine, according to Hutchinson, was encountered at a depth of 20 feet from the surface and increased in strength to a depth of 200 feet. Hutchinson also gives an analysis of the Solomon City salt.

[83] Martha B. Caldwell, "Exploring the Solomon River Valley in 1869", *Kansas Historical Quarterly*, v. 6, p. 61 (1937). The explorer was Robert McBratney, who kept a journal of his trip, a portion of which is copied above.

[84] Andreas-Cutler, *op. cit.*, p. 692.

[85] Kirk, "Kansas Salt" *loc. cit.*, p. 77. A type of salt producing plant similar to the Solomon City work is reported to have begun production at Alma, Wabaunsee County, in 1874 (*Third Annual Report of the State Board of Agriculture*, Topeka, 1874, p. 107). Analysis of the salt obtained is given and the brine well was 585 feet deep, brine being first struck at 185 feet.

summer of 1887 a number of these organizations were actually at work. Although the immediate objects, gas and oil, were not found in any quantity, numerous reports of thick salt beds, five and six hundred feet and more below the surface, began accumulating in considerable number and by the next year drillers had encountered the salt beds at Ellsworth, Kingman, Anthony, Lyons, Hutchinson and elsewhere.[86]

The first discovery of the salt bed at Hutchinson was made by Ben Blanchard on September 27, 1887.[87] Failure to find oil and gas must have dampened the spirits of the oil and gas enthusiasts but, in a country bound to be optimistic at all costs, the discovery of salt was hailed with satisfaction. Two days after Blanchard's discovery, the Hutchinson *News* reported:

SALT FOR THE WORLD

ANOTHER IMMENSE VEIN OF RARE PURITY PASSED THROUGH YESTERDAY—THE OPERATORS JUBILANT.

The drill in the experimental well in South Hutchinson passed through another vein of rock salt yesterday morning, showing up a depth of thirteen feet fully equal in purity to the large vein penetrated Tuesday. This makes a total thickness of nearly forty feet of salt, a thin layer of shale lying between the two veins. As usual no admittance to the enclosure was allowed, but it was learned that the indications for oil was so strong as to be exciting. The proprietors of the well are confident that either coal, gas or oil will be found in paying quantities within the next ten days, and the drill will be sent with all rapidity possible. Not so much anxiety is manifested as to the outcome of further experiments, though, as the salt will be a mine of wealth itself, and it will be taken out in immense quantities if nothing more valuable is found.

Experts claim that the salt can be raised at a cost of less than seven cents a bushel, while the usual market price is in the neighborhood of twenty-five cents. With millions of bushels in sight, it is thus seen what a bonanza is at our doors. The annual production of salt in this country is about thirty million bushels, and we import an additional fourteen million bushels. The demand is always greater than the home supply, so an over production is improbable. In England, one rock salt mine alone employs over twelve hundred men, and its product is largely shipped to the United States. A few more such finds as the Hutchinson mine will make England withdraw from the American market.[88]

Despite this optimism, no immediate steps were taken to start production of salt until a New York firm, Gouinlock and Humphrey, attracted by the discovery of large reserves of salt in Kansas, began

---

[86]For the detailed history of this period, see Robert Hay, "Salt" *Sixth Biennial Report of the Kan. State Board of Agri.* 1887-88, Part II, Topeka, 1889, pp. 199-201; Kirk, "Kansas Salt" *loc. cit.*, pp. 78 et. seq. and Frank Vincent "History of Salt Discovery and Production in Kansas, 1887-1915", *Kansas Historical Collections,* v. 14, pp. 358-378 (1915-1918).

[87]Hutchinson *Daily News,* Sept. 28, 1887, p. 4, c. 2 describes Blanchard's discovery reporting that "yesterday" a vein of pure salt over 20 feet thick was encountered at a depth of 500 feet; see also Vincent, *loc cit.,* p. 359.

[88]Hutchinson *Daily News,* Sept. 29, 1887, p. 4, c. 2.

operations at Hutchinson. By March 23, 1888, this firm was producing salt by hydraulic mining.[89]

It was not long before Gouinlock and Humphrey had competition. In fact, other companies had begun operations or negotiations before salt was produced. Another New York firm began drilling several weeks before Gouinlock and Humphrey were in operation and if one may judge from the contemporary press, Hutchinson was ready for a real boom for the *News* announced:

THE HEN IS OFF

THE BROOD VALUED AT A MILLION DOLLARS
IT COMES ALL FEATHERED OUT, LIFE-SIZE
AND READY FOR THE EARLY BOOM.
ITS MAINTENANCE CAUSES THE DIRECT OUTLAY OF A MILLION
DOLLARS—NEW INDUSTRIES SECURED FOR HUTCHINSON
—A GLANCE AT WHAT IS TO FOLLOW.

This great salt company, the New York salt and mining company, has closed its deal and will spend one million dollars in Hutchinson the next twelve months developing the largest single salt block in the United States. The machinery for drilling the test hole, was moved to the location northeast of the city yesterday, and today the work will be begun.

Do the citizens of Hutchinson realize what this means?

Do they realize that the location here of this New York company, the Gouinlock company and the Hawley company means that one hundred and fifty car loads of salt per day will be shipped out of Hutchinson?

Do they realize that this means that every railroad that comes anywhere near this part of Kansas will make frantic endeavors to get into Hutchinson to get a share of this immense business?

Do they realize that this is to be the great salt center of the west half of the United States, and that the location of these three means that a half dozen more will come?

Do they realize that with this salt block comes a soda ash works that requires a half million of capital? Soda and salaratus works, chemical works and numberless other factories that follow in the wake of salt works?

Do they realize that this means twenty-five thousand people in Hutchinson by next March, and fifty thousand the following March?

Do they realize that this New York company is composed of men who stand among the wealthiest of the U. S., not counting railroad kings, and that they becoming so largely interested in Hutchinson property will be the means of interesting still other capitalists?

Do they realize that "old Hutch" is getting there with both feet and that no power on earth can now stay her progress?

The buildings, warehouses and machinery of this big company will cover twenty acres of land, and is the largest single plant of any kind in Kansas. The various analyses have shown Hutchinson salt to be the purest on the American continent, and with the inexhaustible supply Hutchinson only has to patiently wait two years to become the largest city in Kansas, and the largest manufacturing point in the west.[90]

It is little wonder that with such public optimism, the fame of Kansas was spread abroad. The Philadelphia *Times*, half the continent away, was lead to remark:

But the land of Kansas is a wonder. A town no bigger than a voting

---

[89]Hutchinson *Daily News*, March 24, 1888, p. 4, c. 2 and 3. Dr. W. C. Gouinlock, who had been engaged for 20 years in the manufacture of salt at Warsaw, New York, was the moving spirit in the enterprise.

[90]Hutchinson *Daily News;* March 9, 1888, p. 4, c. 2.

precinct will have street cars and electric lights and corner lights. It just makes a man's back ache to look at Hutchinson, styled the "Queen City". Street car lines running out into the country, several packing houses, salt works and numerous factories going up. The very ground is a quiver with excitement and growth.[91]

How fast the salt boom developed is indicated by Vincent:

Within one year from the date salt was discovered, thirteen plants had been erected, with a total of twenty-nine steel open pans and four steam grainers. The approximate cost or investment was $600,000 with an annual production of 900,000 barrels.[92]

Naturally this great activity in the late eighties brought accompanying changes. Packing houses, as one of the above accounts state, were located and stock yards, creameries and a soap factory were built.[93] The boom finally burst, however, and together with the intense competition, the inevitable decline set in bringing failure, consolidation and reorganization to many of the newly organized salt companies.[94]

The salt industry, operating on a very narrow margin of profit, has indeed been highly competitive. Numerous struggles between competitors have marked the sixty year old industry.[95] The names of such financiers as Jay Gould and of nationally known salt manufacturers may be found in these early operations. Locally formed companies fought "the trust interests" as they were called in the early days and although conciliation efforts were made among the parties concerned, one of the active participants in one of these discussions reported:

It can be truthfully said that the meeting was not of the "peace and harmony" kind. Some of the language used during the discussion was not of a Christian type, nor would it look well in print.[96]

Even as late as 1923, a price war between competitors in Kansas developed and rock salt was offered for the incredibly low price of fifty-five cents a *ton!*[97]

The effect of this active competition is seen in the varying number of plants producing Kansas salt as taken from the decennial United States censuses of manufactures:[98]

---

[91]Reprinted in the Hutchinson *Daily News,* Jan. 24, 1888, p. 4, c. 4.

[92]Vincent, *loc. cit.,* p. 372. The first shaft sunk to mine salt was not included in these earliest of present day activities in this field, but in 1889, Kingman sank the first salt shaft in Kansas (Vincent, *loc. cit.,* p. 376; Zerger, *op. cit.,* p. 74.)

[93]Cowan, *op. cit.,* p. 61; Sheridan Ploughe, *History of Reno County, Kansas,* Indianapolis, 1917, v. 1, p. 337.

[94]Vincent, *loc. cit.,* p. 372. Zerger, *op. cit.,* p. 65, states that 36 companies were incorporated to mine or manufacture salt in the six year period 1887-92.

[95]Vincent, *loc. cit.,* and Cowan, *op. cit.,* discuss many of these varying factions and struggles in Hutchinson, which has been the center of the salt industry in Kansas since 1887. The discussion in the text above is, therefore, essentially that of the industry in Hutchinson.

[96]Vincent, *loc. cit.,* p. 375.

[97]Cowan, *op. cit.,* p. 56.

[98]Quoted by Zerger, *op. cit.,* p. 93.

TABLE 8.—*Producers of Kansas Salt 1890-1940.*

Year	No. of Kansas plants producing salt
1890	23
1900	8
1910	10
1920	12
1930	10
1940	5

Not only did the discovery of large salt reserves in Kansas produce local changes of profound and lasting importance, but the discovery, on a lesser scale, was of international importance as well. In 1880, the United States was importing from abroad more than half as much salt as she produced. Within five years after the discovery of salt beds in Kansas, imports had dropped to one seventh of the United States production of salt and progressively declined until now salt imported is a negligible factor as compared to our total production.[99]

At the present time, the Kansas producers of salt are:[100]

TABLE 9.—*Producers of Salt in Kansas, 1946.*

Company	Home Office	Kansas Plant Location	Type of Production
American Salt Corp.	Kansas City, Mo.	Lyons	Evaporated and rock salt
Barton Salt Co.	Hutchinson, Kans.	Hutchinson	Evaporated salt
Carey Salt Co.	Hutchinson, Kans.	Hutchinson	Evaporated and rock salt
Carey Salt Co.	Hutchinson, Kans.	Lyons	Evaporated and rock salt
Independent Salt Co.	Chicago, Ill.	Kanopolis	Rock salt
Morton Salt Co.	Chicago, Ill.	Hutchinson	Evaporated salt
Morton Salt Co.	Chicago, Ill.	Kanopolis	Rock salt

Data on the total production of salt in Kansas and its value is given in the table which follows. The figures for all years are not available and some, as is true in any such statistical summary, do not justify the number of significant figures which have been employed in the original compilations. The rank of Kansas among the states in salt production and in value of salt produced for each year is also included.

For the past five years (1941-45 inclusive) Kansas has produced six per cent of the nation's total salt, although in years past this figure has risen occasionally to ten per cent. The change in rank after 1903 in terms of total production has been due to the development, first of Ohio as a salt producing state, and later to increased production in Louisiana and Texas. The discrepancies between rank in production and rank in value, especially noticeable during the years 1943 and 1944 seem curious. Inquiry directed to the statistician of the

[99]Phalen, *Salt Resources*, et. cet., *op. cit.*, pp. 252 and 268; Harris and Tucker, *Salt*, *op. cit.*, p. 8.

[100]The source of the data in Table 9 is the *Minerals Yearbook, Review of 1940*, p. 1378, where a directory of U. S. salt producers is given. Changes in the industry have been given in subsequent issues of *Minerals Yearbook*, 1941-45 inclusive. In 1945, the American Salt Corporation had the misfortune to loose by fire their salt refining plant. The plant is being rebuilt and it is expected that it will be in operation early in 1947.

TABLE 10.—*Value and Quantity of Salt Produced in Kansas, 1880-1945.*[101]

Year	Salt Produced in Kansas Short Tons	Value	State Rank in production	State Rank in value
1880	364	$ 5,700	13	14
1888	21,700	189,000	8	4
1889	63,000	202,500	3	3
1890	123,573	397,199	3	3
1891	119,775	304,775	4	3
1892	207,214	773,989	3	3
1893	178,805	471,543	3	3
1894	193,537	529,392	3	3
1895	187,826	483,701	3	3
1896	197,205	397,296	4	4
1897	215,366	488,022	4	3
1898	263,526	616,591	3	4
1899	230,349	546,291	3	4
1900	312,743	1,076,045	3	3
1901	292,291	614,365	3	3
1902	302,188	514,401	3	4
1903	217,831	564,232	4	4
1904	302,655	717,101	4	3
1905	293,802	576,139	4	3
1906	307,837	681,022	4	4
1907	373,444	962,334	4	4
1908	362,434	882,984	4	3
1909	387,779	782,676	4	4
1910	393,603	947,369	4	4
1911	302,380	806,027	4	4
1912	360,308	844,292	4	4
1913	377,731	860,404	4	4
1914	415,501	924,550	4	4
1915	527,123	1,035,879	4	4
1916	639,071	1,302,359	4	4
1917	746,976	2,027,466	4	4
1918	819,504	3,598,289	4	3
1919	773,576	4,497,247	4	3
1920	783,655	3,839,409	4	3
1921	665,968	3,268,661	4	4
1922	759,459	3,849,427	4	3
1923	845,163	3,570,135	4	4
1924	794,303	2,781,217	4	4
1925	812,540	2,494,423	4	4
1926	729,880	2,741,534	4	4
1927	794,780	2,971,544	4	4
1928	821,950	3,573,982	4	3
1929	840,370	3,761,984	4	3
1930	759,800	3,148,728	4	3
1931	691,160	3,003,756	4	3
1932	648,800	2,876,239	4	3
1933	732,947	3,039,343	4	3
1934	768,133	2,949,930	4	3
1935	608,204	2,309,482	5	5
1936	704,164	2,580,166	5	3
1937	654,089	2,759,062	5	4
1938	597,909	2,565,447	5	4
1939	641,752	2,591,934	5	5
1940	684,053	2,710,847	5	5
1941	781,014	3,254,828	5	4
1942	860,083	3,809,321	5	4
1943	945,287	4,197,507	6	3
1944	932,238	4,357,217	6	3
1945	855,806	3,837,850	6	5
Total	30,224,524	$112,465,153		

United States Bureau of Mines concerning this discrepancy brought the following explanatory reply for the data in the *Yearbook* of 1944:

> The value of salt sold or used as given in the Minerals Yearbook is the value at the place of production not including cost of containers,

[101]The data from 1880-1917 inclusive in the above table are based upon Phalen, *Salt Resources of the United States, op. cit.*, pp. 257-262, recalculating the production from barrels (as Phalen reports it) to short tons (1 barrel of salt=280 lbs.); from 1918 to 1931 inclusive the data are taken from the annual volumes of *Mineral Resources of the United States* published by the United States Geological Survey; the data from 1932-1945 inclusive are from the annual volumes of the *Minerals Yearbook*, published by the U. S. Bureau of Mines.

packaging or freight charges. Accordingly, freight does not enter into the problem except insofar as a low freight rate might give a producer a price advantage in distant markets.

The high average unit value of salt sold in Kansas is evidently due in part to the fact that Kansas produces no salt-in-brine, which is a very low-priced product, whereas Michigan, Ohio, and New York produce large quantities of brine which enter directly into chemical processes without evaporation. Furthermore, a substantial proportion of the salt output of Kansas is evaporated salt which commands a much higher price than either rock salt or salt-in-brine. As the state totals are a summation of all three types of salt a preponderance of the higher-priced products would automatically result in a relatively high unit value.

The unit value of evaporated salt in Kansas is the second highest among all the states; New York is the highest. The differences in return received per ton in different states is probably due to variations in costs of mining and preparation.[102]

Although freight rates do not enter into the valuation of Kansas salt as listed in Table 10, they have played an important part in determining a market for Kansas salt and have accounted for many of the serious conflicts between producers of salt in Kansas.

One such serious difficulty arose in the early nineteen hundreds and was exclusively a home affair but the Interstate Commerce Commission has been called upon many times to render decisions between interstate producers of salt in the attempts of each to enlarge their sales territory. Possibly the most famous of these cases was the decision of the Commission in 1924 which permitted rates so that Kansas salt could compete more favorably with the Michigan salt producers for the Chicago market.

Later (1926) Texas and Louisiana entered complaints with the Commission asking for adjustment of railroad rates that would enable them to compete with Kansas salt in the Omaha (another large packing center) market. According to Zerger, the situation at present is such that

> In effect, Kansas salt companies have been given a virtual monopoly over Kansas, southern Nebraska, western Missouri, eastern Colorado, and northern Oklahoma. Favorable conditions have been created for competition with other salt producing areas in remaining portions of Nebraska, Missouri, Colorado and Oklahoma; and in Iowa, South Dakota, North Dakota, Minnesota, Montana, Wyoming, New Mexico, Texas, and Arkansas.[103]

In practical agreement with this summary, in 1939, one of the leading Kansas producers in a letter to the writer, stated that, of their total production, 95 per cent was shipped out of the state to points in Oklahoma, Arkansas, Missouri, Iowa, Illinois, Minnesota, South Dakota, Montana, Wyoming, Colorado, New Mexico, Texas and Arizona.

[102]Letter to the writer, Nov. 20, 1946, from Thos. H. Miller, Acting Chief, Economics and Statistics Branch, U. S. Bureau of Mines.

[103]Zerger, *op. cit.*, p. 128.

The most recent regulatory act on railroad rates went into effect in 1945 and the result it will have on the marketing of Kansas salt remains to be seen.[104]

Consumption of salt in Kansas. In recent years the *Minerals Yearbook* has published data that enable a rough estimate to be made of salt consumed within the state. These compilations of the *Yearbook* are reached by adding together the salt shipped to destinations within the state by producers within the state and the salt shipped into Kansas by producers of salt in other states. It does not take any account of re-shipments beyond the original destination.[105]

It may be pointed out that shipments in and into Kansas may not equal consumption of salt during a given year but as this commodity is not stored for any great length of time, such annual records as cited below afford the only available index of salt consumption in the state.

TABLE 11.—*Shipments of Evaporated and Rock Salt In and Into Kansas, Short Tons.*

Year	Evaporated Salt	Rock Salt	Total
1932	36,742	112,094	148,836
1933	37,974	120,403	158,177
1934	35,946	148,606	184,552
1935	26,894	126,013	152,907
1936	28,405	132,114	160,519
1937	40,948	137,605	178,553
1938	37,542	120,527	158,069
1939	26,577	131,499	158,076
1940	36,825	162,612	199,437
1941	39,225	211,447	250,672
1942	51,543	175,486	227,029
1943	61,604	174,363	235,967
1944	65,272	153,498	218,770
1945	54,644	130,090	184,734

Comparison of these figures with those of production of salt for the same years shows that Kansas produces on the average four or five times as much salt as is used within the state and the question has frequently been raised if methods could not be found that would enable a more profitable return on Kansas salt by converting it into other and higher priced products. Several solutions of such problems have been attempted and the results are briefly reviewed below.

In 1906, local business men in Hutchinson organized a com-

[104]Zerger, *op. cit.*, p. 112. Information on freight rates and the history of Kansas salt will be found in Sheridan Ploughe, *History of Reno County, Kansas* (Indianapolis, 1917) v. 1, pp. 366-371; F. Evan Johnson, *Railroad Rates in Relation to the Marketing of Kansas Salt*, Master's thesis, University of Kansas, 1928, 49 pages (Johnson gives a summary (p. 46) of the cases dealing with freight rates on salt for the period 1891-1927); Zerger, *op. cit.*, Chapter VII.

[105]That is, a producer may consign a given quantity of salt to a dealer within the state (an original shipment). If the dealer then ships it out of the state no record of such re-shipment is available to the Bureau of Mines. It should be remarked, again that the data in Table 11 are only a rough approximation as returns from all producers of salt in Kansas are not included in the compilations reported in the various issues of the *Minerals Yearbook.*

pany for producing soda ash from Hutchinson salt and limestone from nearby Marion County. It was hoped that soda ash thus produced would be able to supply the middle west with this material so extensively used in the manufacture of glass and soap and in the textile and paper industries. A plant was erected at a cost of approximately a half-million dollars and began production in 1909. In 1910, Emerson Carey, the founder of the Carey Salt Company, became president of the soda ash organization which was reportedly producing soda ash at a profit. In the same year, however, the Solvay Process Company of Syracuse, New York, the leaders in soda ash production in this country, bought the Hutchinson plant at a price of approximately $600,000. The Solvay organization continued production of soda ash at Hutchinson and by 1916 or 1917 it had become one of the biggest industrial organizations in Hutchinson employing 500 people and producing over 50 tons of soda ash daily.[106]

After World War I, the Solvay people decided to discontinue operations and on Oct. 1, 1921, the plant was shut down as an operating unit. The plant then remained idle until August, 1942, when the Solvay organization sold the equipment to a wrecking company and the real-estate owned by Solvay was disposed of to local individuals.[107] From the fact that soda ash could be profitably made in Kansas for a dozen years suggests that the possibility of its production again would be worth re-investigation.

In 1940, Mr. Arthur Thomas, Jr., a chemical engineer at the University of Kansas, made a detailed study on the possibility of producing chlorine—at a profit—from Kansas salt. After considering various possible plant locations for the proposed enterprise, Rice County was selected. Factors considered were water sources, transportation facilities, depth and thickness of salt beds, and abundance of natural gas (the source of power). The physical valuation of a proposed five-ton-per-day chlorine plant was estimated at approximately half a million dollars and the cost of production calculated. Thomas reasoned that the products of such a plant would be equivalent to their consumption in the state in 1940 and on such a basis, the plant could not offer the possibility of a return on the investment. If such a plant could supply products then consumed by the states

[106]Richard L. Douglas, "A History of Manufacturers in the Kansas District", *Kansas Historical Collections*, v. 11, p. 180 (1909-10) Sheridan Ploughe, *op. cit.*, v. 1, pp. 377-379.

[107]Letter to the writer, Aug. 7, 1944 from Mr. D. O. Yeoman, assistant director of operations, The Solvay Process Company, Syracuse, New York. Mr. Yeoman was one of the plant chemists at Hutchinson from 1913 until it closed down in 1921.

of Oklahoma and Texas as well as Kansas, economic feasibility might be realized.[108]

In addition to chlorine, the products of the plant considered by Thomas would include caustic soda (sodium hydroxide) and muriatic (hydrochloric) acid. The possibility that chlorine could be immediately used on the plant site for the production of other materials (than muriatic acid) was not considered. More recently, however, investigators G. W. Stratton and D. E. Winkler, also of the University of Kansas, have shown that it is possible to produce from chlorine and Kansas natural gas, high grade carbon black and activated carbons, such as are used in large quantities in the production of rubber products (including tires) and industries requiring commercial adsorbents.[109] The economic possibilities of such a process, in conjunction with a chlorine plant, have not been studied.

Additional uses and consumption of Kansas salt can only be had by such long and detailed investigations as those described above and the willingness of Kansas capital to invest in such enterprises once their economic possibility has been established.

The status of the salt industry in Kansas in 1939, just before the abnormalities produced by the entrance of this country into World War II, can be summarized from the data included in the last (16th) United States census records:

TABLE 12.—*The Salt Industry in Kansas, 1939.*[110]

Number of establishments	5
Persons employed by manufacturers	603
Salaries and wages	$ 722,569
Cost of materials, etc.	$1,154,423
Value of products	$3,067,139
Value added by manufacture	$1,912,716

In addition to the above data, one of the leaders in the salt industry in Kansas states[111] that as "a rough guess the investment in salt plants and mines, exclusive of inventories, such as packages, etc., in the state of Kansas would be approximately 7 million dollars."

[108]Arthur Thomas, Jr., *The Economic Feasibility of Producing Electrolytic Chlorine Utilizing the Salt Deposits of the State of Kansas and Natural Gas as a Source of Energy,* Master's thesis, University of Kansas, Lawrence, June, 1941, 113 pp.

[109]Deloss E. Winkler and George W. Stratton, *The Production of Carbon Black and Activated Carbon from Hydrocarbons and Chlorine,* University of Kansas Publications, Industrial Research Series No. 3, Lawrence, 1942, 38 pages. Winkler and Stratton point out that carbon black produced in their trials were not equal in quality to carbon blacks then in use in the tire industry. Distinct evidence was available, however, that indicated modification of experimental procedure would result in greatly improved materials.

[110]*Sixteenth Census of the U. S. — Manufactures 1939,* Washington, 1942, v. 3, p. 336.

[111]Letter to the writer, August, 1944.

Acknowledgements

The writer wishes to thank the many officers of the various salt-producing companies in Kansas for their generous and willing co-operation in furnishing information and aid of real value in the preparation of this review. He is also indebted to his colleagues, Drs. W. H. Schoewe and John Frye of the State Geological Survey, for advice and suggestions in the preparation of the manuscript. Any errors of omission or commission in the review, as it here appears, however, are chargeable to the writer alone, for it would take more than two geologists to make one stubborn chemist change his mind.

The Editor's Page

Transactions
of the
Kansas Academy of Science
Published Quarterly
by the
KANSAS ACADEMY OF SCIENCE
(Founded 1868)
OFFICERS
Claude W. Hibbard, Lawrence, President.
F. C. Gates, Manhattan, Secretary.
S. V. Dalton, Hays, Treasurer.

VOL. 49, No. 3 DECEMBER, 1946

ROBERT TAFT, *Editor*

Within the past few weeks it has been announced that the state lake at Tonganoxie, Leavenworth County, would be drained to ascertain, if possible, the causes of poor fishing encountered in recent years. No fishing at Tonganoxie will be possible in 1947 nor possibly in 1948. This situation again brings to the forefront the matter of conservation in all its aspects in the state.

Public interest in out-door recreational facilities, it is evident from many sources, is growing, not abating. The lakes of Kansas, as Dr. Stene pointed out in the September issue of these *Transactions*, were built as a result of insistent popular demand. Recently, too, the wild life conservation committee of the American Legion in Kansas presented a series of recommendations on wild life conservation to the candidates for the governorship in the elections just passed.

The *Transactions*, both through its articles and its notes, has advocated for a number of years many of the same recommendations endorsed by the American Legion. Great increases in our knowledge of the many aspects of conservation are necessary; a knowledge to be gained only through systematic study by scientifically trained personnel. To take the matter of fishing alone, Dr. John Breukelman wrote only last June in these *Transactions*: "No extensive researches have been conducted in Kansas, but casual and scattered observations indicates that several of the lakes are seriously overpopulated, in terms of space, food supply, spawning areas, and other necessities of normal aquatic life.—It is highly probable that careful ecologic studies of new artificial lakes would yield information that would help to maintain a better permanent population of fish and other aquatic life."

If the matter of need of scientific study and management alone is not sufficient to arouse public and legislative action, a consideration of state pride might lend aid to our argument. All of our neighboring states, Nebraska, Colorado, Oklahoma and Missouri have already made consid-

erable advances in establishing scientific conservation plans. Oklahoma and Missouri especially have been making scientific studies of wild life, both plant and animal, for some years. How extensively Missourians are considering conservation in its broadest terms is shown by the fact that plans for the re-forestation of 15 million acres of land —nearly one-third the area of the state—are now under way. Land not under cultivation or land occupied by scrub oak and useless plant growth is to be planted to trees yielding marketable lumber. This huge re-forestation program will be developed in cooperation with soil conservation plans, with game and wildlife management and control, and with state-wide beautification plans for parks, highways and local botanical gardens.

Should Kansas be any less willing than Missouri in developing plans for the use, improvement and beautification of her outdoors? Not that we can follow Missouri in any such extensive re-forestation project but certainly the study, inception and application of a long-range program of complete conservation by competent and trained personnel for Kansas conditions is now in order.

* * *

And while we are writing about conservation, we might look beyond our regional boundaries and call attention to impending Federal action. According to recent writers, if legislation in the United States Congress is passed, our national parks and national forests are in grave danger. Ralph W. Page on the editorial page of the Kansas City *Times* for November 26, 1946, calls attention to the fact that private interests are attempting to gain control of these national treasures — treasures that belong to you and to me. For nearly seventy-five years, our national parks have brought deep and satisfying pleasure to countless Americans and our park system has made the United States unique among the nations of the world.

If you desire still more information on the national calamity that would result from private control of our parks and forests read Bernard DeVoto in *Harper's Monthly* for January, 1947, "The West Against Itself."

Should not Academy action be taken in this matter? Let's have a strong recommendation from our conservation committee at the annual meeting.

* * *

The estimate of exceptional children in Kansas, made in Dr. Homer B. Reed's paper in this issue (see page 333) of the *Transactions,* appalls one. It seems certain that as a lower limit there are over 50,000 children in the state in need of special aid because of physical and mental disability; a fact that calls for a sense of public responsibility that none of us can escape. The only bright aspect of the picture is the large number of mentally gifted youngsters (over ten thousand) who give promise—if properly stimulated and trained—of great return on any investment in their future which we are willing to make.

Scientific News and Notes of Academy Interest

Items for this column are solicited from all Academy members. For inclusion in any given issue they should be in the editor's hands at least three weeks before our publication dates, namely the fifteenth of March, June, September and December.

The 79th annual meeting of the Academy will be held at Lawrence on April 2, 3, and 4, 1947. Indications at present point to one of the largest meetings in the history of the Academy. Several other organizations are planning on meeting with us. Plan now to be present.

Dr. F. C. Gates, past president of the Academy and former editor of these *Transactions*, has kindly agreed to serve as secretary of the Academy in filling the remainder of the term of Dr. S. M. Pady, who resigned the secretaryship after his removal to McGill University.

Dr. and Mrs. Charles E. Burt of the Quivira Specialties Company, Topeka, spent the period from November 22 to December 4 on a collecting trip in the Texas mountains west of Pecos. Twelve thousand resurrection plants and 3,000 cacti were obtained for their collections.

Prof. L. P. Reitz of the agronomy department, Kansas State College, Manhattan, and senior agronomist of the State Agricultural Experiment Station, resigned his position January first to become coordinator of hard red winter wheat improvement for the U. S. Department of Agriculture with headquarters at Lincoln, Nebraska.

Rev. W. C. Doyle, S. J. of Rockhurst College, Kansas City, Missouri, was elected president of the Missouri Academy of Sciences at the annual meeting of the Academy at Rolla, Missouri, on November 1 and 2. Dr. L. J. Gier of William Jewell College, Liberty, Missouri, was elected chairman of the biology section.

Dr. Ivan L. Boyd of the biology department, Baker University, Baldwin, and Dr. Donald Farner, University of Kansas, attended the annual meeting of the Wilson Ornithological Club held at Omaha during the Thanksgiving holidays. The meeting was sponsored by the Nebraska Ornithologists Union and was attended by some 125 members and visitors, including a number of bird artists. One of the features of the meeting was the display of sketches and paintings by some 30 of these artists. One of the activities sponsored by the Wilson Club was the reactivation of state bird associations that have become inactive during the war. Included in this group is the Kansas Ornithological Club. Anyone who can furnish information on the last records of the Kansas club is earnestly requested to communicate with Dr. Farner or Dr. Boyd.

Dean R. I. Thackrey, dean of administration, Kansas State

College, Manhattan, resigned his position January 1 to accept a position as executive secretary of the Association of Land Grant Colleges and Universities, Washington, D. C.

Dr. Robert M. Dreyer, associate professor of geology, University of Kansas, has been awarded a joint research grant of $6,700 with Dr. A. L. Howland and Dr. R. M. Garrels of Northwestern University, for basic research in the formation of minerals. Dr. Dreyer will undertake, as his share of the project, mineralogical and petrographical examination of minerals and ores, while geochemical studies will be made at Northwestern.

Dr. John C. Frazier, Kansas State College, Manhattan, attended the A.A.A.S. meetings at Boston during the Christmas holidays, serving as Academy representative.

Dr. and Mrs. T. D. A. Cockerell, left Denver on September 29 for an extended stay at the Escuela Agricolo Panamericana, Tegucigalpi, Honduras. Their trip was made by air and required less than 24 hours for its completion. Dr. Cockerell is engaged in a study of the insects of this region which he reports have not been much collected or studied. The Escuela, essentially an agricultural school, is supported by the United Fruit Company who have contributed three-quarters of a million dollars to the enterprise. Among the faculty, Dr. Cockerell mentions especially Mr. L. Williams, a botanist who is an authority on orchids and who has made extensive collections in Brazil and Panama.

Dr. F. W. Albertson, vice-president of the Academy, Kansas State College, Hays, has been confined to his home for some weeks with a throat and sinus infection. His many friends will wish him a speedy recovery.

Among recent staff changes at Southwestern College, Winfield, are the appointments of Dr. Russell Grow, formerly of the University of Tulsa, as professor of psychology and dean of the college; of Dr. M. M. Keith as professor of biology and head of the division of natural sciences; and of Mr. Asher Kantz as acting head of the physics department.

Dr. Roger C. Smith served as chairman of the teaching section of the American Association of Economic Entomologists at the annual meeting December 9-12 at Richmond, Va. Dr. W. P. Hayes, a former member of the Kansas Academy of Science, now acting head of the department of entomology, University of Illinois, who was secretary of the teaching section, cooperated with Dr. Smith in preparing the program. Dr. Kathleen Doering of the University of Kansas was on the program and discussed better teaching in the insect taxonomy laboratory.

Dr. Smith was elected first vice president of the Entomological Society of America at the Richmond meetings, councillor of the A.A.A.S. and representative of the American Association of Economic Entomologists

to Section F and appointed chairman of the program committee of the north central states branch for the meeting at Des Moines, March 25-26, 1947. He continues as a member of the committee on popular entomological education.

Dr. J. Lawrence Oncley, a graduate of Southwestern College in the class of 1929, has recently been appointed associate professor of physical chemistry at Harvard Medical College. Dr. Oncley is the son of Professor Lawrence Oncley, past-president of the Academy and professor of chemistry at Southwestern College.

Miss Margaret Parker has been appointed assistant professor in the department of physical science at Kansas State Teachers College at Pittsburg, and will teach courses in chemistry and physics. She received her masters degree in physical science from the College, and has had experience in public school teaching and industry. Before joining the staff at the College, she was employed by the Kansas Gas and Electric Company.

Dr. Ralph L. Parker, state apiarist, presented a paper, "Trade Barriers in the Beekeeping Industry" and represented the Kansas Entomological Commission at the annual meeting of the Apiary Inspectors of America at the National Federation of Beekeepers' Associations annual meeting in Tampa, Florida, Jan. 13-17, 1947.

Dr. Harry Truman resigned as professor of biology at Southwestern College this past fall to accept a similar position at Fort Hays Kansas State College.

A course in the chemistry and manufacture of plastics is now being offered at Kansas State Teachers College in Pittsburg as a cooperative project of the departments of chemistry, physics and industrial arts. Dr. L. C. Heckert is head of the department of physics and chemistry, Dr. O. A. Hankammer is head of the department of industrial arts, and Professor W. H. Matthews is acting as coordinator for the project.

Dr. T. F. Watson will become professor of physics at the University of Wichita, beginning with the second semester, January 28. Dr. Watson has been serving as professor and head of the physics department in Phillips University, Enid, Oklahoma. He obtained his B.A. degree at the University of Oklahoma in 1928, and remained there to complete his M.S. degree in 1930. From 1930 until 1935 he served as department assistant at the University of Illinois and received his Ph.D. degree from that institution. He was professor of physics at Northeastern State College, Tahlequah, Oklahoma, from 1935 to 1943 and for one year taught in the military program at Oklahoma A. and M. College. He has been at Phillips since 1944.

A new comprehensive course in fundamentals of physical science is now being offered at

Kansas State Teachers College in Pittsburg under the direction of Professor W. H. Matthews, in connection with the reorganization of the general education program there. Copies of the syllabus of the course may be procured by writing to Dr. Ernest Mahan, dean of instruction. Dean Mahan has suggested that he would be especially glad to exchange outlines with other institutions that are offering courses of a similar type.

Many members of the Academy would be interested in *Education: America's Magic* by R. M. Hughes and W. H. Lancelot, published recentlv by Iowa State College Press and priced at $2.50. The book includes a ranking of the 48 states on their educational achievements as indicated by the use of a series of criteria employed by the authors. The criteria include not only actual performance but also financial ability to support education and effort and efficiency in the use of educational resources. The authors rank Alabama, Arkansas and Mississippi above Delaware and Maryland, which rank high in financial ability but low in other respects. Although the author's rankings of the 48 states are liable to objection and reproof, they and the data on which they are based are informative and suggestive. In addition to the material on state rankings, the book contains interesting chapters on progress through education, Federal responsibility, interstate migration and its educational implications and various other important subjects.—F.D.F.

Mr. Edwin C. Hyatt has joined the permanent staff of the University of Wichita Foundation for Industrial Research as industrial hygienist. A graduate of the University of Kansas, Mr. Hyatt for three years was industrial hygienist for the Kansas State Board of Health and later was chief of the industrial hygiene division of the Missouri State Board of Health. He has done graduate work at the University of Kansas and in the Harvard School of Public Health. Immediately prior to coming to Wichita, Mr. Hyatt was on the staff of the Industrial Hygiene Foundation of Mellon Institute.

In response to a recommendation passed in the psychology section of the Academy at the 1946 meeting, a merger of the Kansas Psychological Association, which functions as the psvchology section of the Academy, and the Kansas Association of Consulting Psychologists is in the process of being worked out. This duplicates on a state level the recent merger of the American Psychological Association and the American Association of Applied Psvchologists into the newly organized American Psychological Association on the national level. The newlv formed national organization has made provision for the affiliation of state groups, recommending that such groups accept the new state organization, although a sub-division made up of those who are working more specifically in the field of applied psychology mav be formed. This would follow the structural pattern of the na-

tional association. Dr. James Coleman, of the University of Kansas, and Dr. Albert Voth, of the Topeka State Hospital, are representing the Kansas Psychological Association in writing a constitution for the new state organization, while Dr. Bert Nash, of the University of Kansas, and Dr. Paul Murphy, of Kansas State Teachers College at Pittsburg, are acting for the Kansas Association of Consulting Psychologists. This constitution will be acted upon at the spring meeting of the Academy.

Dr. Waldo B. Burnett, director of the University of Wichita Foundation for Industrial Research, has been elected president of the newly organized Wichita Council of Technical Societies. The announced purpose of the council is "to provide a medium for cooperative action among those engineering and scientific groups on matters of mutual interest which are beyond the scope of individual societies or which can be performed better by joint action." The council includes the Wichita membership of: American Association of Cereal Chemists, American Chemical Society, American Institute of Electrical Engineers, American Society for Metals, American Society for Tool Engineers, American Welding Society, Institute of Aeronautical Sciences, Society of Aircraft Structural Engineers, Society of Automotive Engineers, Wichita Engineers Club and Wichita Society of Professional Engineers.

Dr. W. M. Jardine, president of the University of Wichita, continues steady improvement in his convalescence following the serious illness which he experienced early this fall. Dr. and Mrs. Jardine sailed December 28, from San Francisco for Honolulu, where they will have an extended visit with their son and his family.

A science, industry, and agriculture clinic will be held at Kansas State Teachers College in Pittsburg in April under the joint sponsorship of the College, Pittsburg Chamber of Commerce, and Kansas State Chamber of Commerce. The emphasis will be upon the application of recent scientific discoveries to industry and agriculture.

Professor Robert B. Dunlevy, for many years professor of geology at Southwestern College, Winfield, has retired from active duty with the rank of professor emeritus.

Mr. Blaine E. Sites, who spent the summer of 1946 teaching in the physics department of Kansas State College, Manhattan, is continuing his work as physics instructor in the Salina High School. Mr. John R. Sites, who has been employed at the well-known project at Oak Ridge, Tennessee, for several years has returned to Kansas State College as graduate instructor and student in the physics department.

Dr. A. B. Cardwell, head of the physics department, Kansas State College, Manhattan, and associate editor of these *Transactions,* has been filling a number

of speaking engagements about the state in recent months. Dr. Cardwell, a physicist at Oak Ridge during the war, has been discussing various aspects of the problem of nuclear energy.

Mr. Ralph Krenzin, research assistant in agronomy, Kansas State College, Manhattan, has rejoined the faculty at Manhattan after a leave of absence for military service.

Dr. Waldo R. Wedel, associate curator of archeology, the Smithsonian Institution, Washington, was actively engaged during the summer of 1946 in archeological studies in the Missouri River Valley. As a number of sites explored lie within the Kansas region, the editor has asked Dr. Wedel to prepare the following brief account of the work of the past summer. Dr. Wedel writes:

The archeological fieldwork of the Smithsonian Institution in the Missouri River Basin during the past summer represented the first phase in one of a series of surveys planned for river basins where flood control, irrigation, and power development will result in destruction of numerous archeological sites. The investigations were carried on in cooperation with the National Park Service, the Bureau of Reclamation, and the Army Corps of Engineers.

Within the 530,000 square miles of the Missouri River watershed, construction of more than 100 reservoirs has been proposed. Widely scattered along the mainstem and on many of its tributaries, these will erase forever Indian habitation sites ranging in time from the earliest human occupancy of the region to those seen by Lewis and Clark and other travelers in the 19th century. The work of the Smithsonian is planned to locate the sites in each proposed reservoir, to select those of primary importance, to carry on intensive excavations in such key sites, and to publish reports on the findings. Collections resulting from the work will be divided between the Smithsonian, National Park Service recreation area exhibits, and established state and local museums.

The preliminary survey in August and September, 1946, disclosed the location of approximately 170 archeological sites, as well as fossil deposits of importance. It is expected that a great many more will be found when work is extended to the huge mainstem reservoirs in South Dakota next spring, and when more intensive investigations are possible at the tributary reservoirs visited in the past summer.

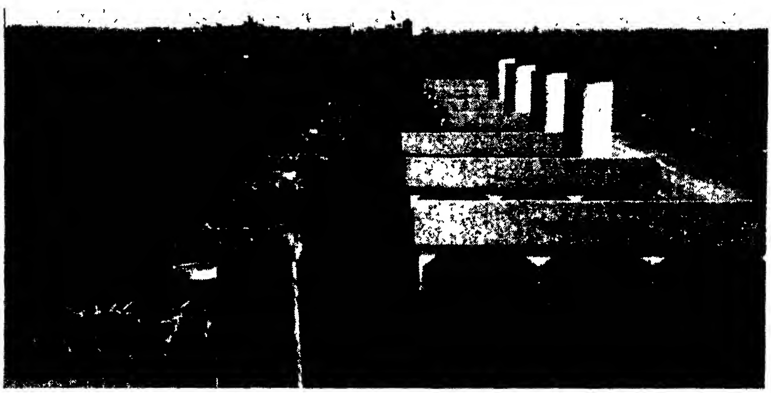
Localities visited in Kansas include Kanopolis, Cedar Bluff, and Kirwin projects. The Kanopolis unit contains numerous archeological remains; and since it is more than half completed, further work at an early date will be required. Cedar Bluff and Kirwin do not seem promising. During October and November, a small party made test excavations on Prairie Dog Creek near Woodruff, Kansas, at the upper end of one arm of Harlan County, Nebraska, reservoir on the Republican. A prehistoric burial ground and sev-

eral important village sites were explored; further work will probably be needed.

The present field headquarters and laboratory of the Missouri River Basin survey are at the Laboratory of Anthropology, University of Nebraska. A staff of six archeologists is currently preparing reports on last season's findings. It is expected that one or more paleontologists will be added by next spring or summer. Because of the probable magnitude of the program, it is hoped that the active aid and cooperation of all state and local agencies interested in the archeology, paleontology, and history of the region can be enlisted.

The eighth in our series of brief reviews of research centers in the Kansas area describes the Fort Hays Experiment Station. The account of the Fort Hays Station which follows was prepared by Superintendent L. C. Aicher, director of the Station and a member of the Academy.

The Fort Hays Experiment Station was established on the old Fort Hays Military Reservation by legislative enactment in 1901. At the present time, 3,264 acres comprise the Station property, 1,442 of which is under cultivation, 1,622 in pasture and the remainder in creek bed, woodland, roads, building sites and feed lots. In addition, there are 410 acres of land infested with bindweed leased from the Fort Hays Kansas State College for experimental studies in the eradication of this serious weed pest. The Station is equipped to conduct experimental work with soils, crops, livestock, horticulture and forestry.



Experimental Feed Lots, Fort Hays Experiment Station. The City of Hays Appears in the Background.

(A) The crops, soils, fertilizer, water conservation and noxious weed control investigations are all carried on in co-operation with the Bureau of Plant Industry or the Soil Conservation Service of the U. S. Department of Agriculture. The U. S. Department of Agriculture sup-

plies the technical personnel on all these co-operative projects except that of soil and moisture conservation.

Cereal Investigations cover investigations with sorghums, winter wheat, winter and spring barley, oats and corn to determine varieties best adapted to this section of the state. Plant breeding work is extensively conducted with sorghums and considerable plant breeding work with winter wheat is under way. This sorghum breeding and selection work to date has accounted for the release of Pink Kafir, Early Sumac, Wheatland, Norkan, Early Kalo, Midland and Cody sorghums from this Station. There were over a million and a half acres of Midland grown in Kansas this year.

Forage Crops and Disease Studies at this Station include investigations with grasses, alfalfa and sweet clover. Buffalo grass and Blue Grama have received the greatest attention because of their importance in this region. Buffalo grass investigators discovered that it was feasible to harvest Buffalo grass seed after the Station developed proper machinery for the purpose and that, once the seed was harvested, it could be made to grow when properly processed. This Station found that the seed of Buffalo carried a natural dormancy which inhibited germination to the extent that only five to seven per cent of the seed would grow the first year. After several years of trial, a method of overcoming this dormancy was discovered. Soaking the seed in a half of 1% solution of salt peter for 24 hours and then chilling while wet at 40 degrees temperature for six weeks and drying immediately thereafter increased germination over tenfold. The production of Buffalo grass under irrigation has yielded some startling results. The 10-acre field of the Hays selection, this past season, produced 720 pounds of seed per acre. The best native pastures yield from 50 to 100 pounds of seed per acre. This Station maintains the only foundation fields of the new wilt-resistant alfalfa recently released under the name of Buffalo.

Soils and Fertilizer Investigations are concerned with seedbed preparation and crop rotations. In connection with this work, special emphasis is placed on soil moisture determination and thousands of samples have been taken annually, many of them to depths of 10 feet for this purpose. The seedbed investigations have to do with the preparation of the soil in many ways for the planting and production of crops adapted to this area. Many different crop rotations and crop sequences are carried out along with the use of fertilizers and green manure crops. An outstanding contribution from this project is the recent bulletin by A. L. Hallsted—"Reducing the Risk in Wheat Farming in Western Kansas" which presents facts appertaining to the relationship of soil moisture at seeding time and the subsequent wheat crop.

Noxious Weed Control Investigations have been under way at this Station since 1935. This is one of four regional, state, and federal co-operative projects

with plans closely co-ordinated, studying weed eradication on a regional basis. The weed work at this Station serves the entire Southern Great Plains area. The general objective of the weed investigations at Hays has been to develop effective and economical methods for the control of bindweed and other noxious annual and perennial weeds by the use of intensive cultivation, competitive and smoother crops, herbicides and selective chemicals. Several effective and practical methods of controlling bindweed have already been developed and much information has been gathered on the effectiveness of herbicides and chemicals on both annual and perennial weeds.

Soil and Water Conservation Investigations have been continued with special emphasis on losses of water and soil from 5% slopes. The seeding of 10% slopes to grasses to prevent soil losses and the development of grass outlets for terraces has also been carried out with very effective results. All plantings of annual crops have been made on the contour resulting in the reduction of loss of soil and moisture and in increased crop production when compared to crops planted up and down the slope.

(B) Purely State Projects have to do with Beef Cattle Feeding Investigations, Grazing Investigations, State Forest Nursery and Pure Seed Distribution.

Beef Cattle Feeding Investigations are conducted at this Station to determine the relative feeding values of western Kansas feeds for the maintenance and fattening of beef cattle. A very extensive series of tests have been completed during the past 25 years providing a fund of information on the utilization of sorghums both as silage and as dry feeds in combination with various supplements for the maintenance feeding of calves and yearlings. In other words, the wintering of cattle preparatory to going back on grass in the spring or into the feed lot.

A new series of feeding experiments was begun in 1944 comparing the feeding values of the Midland, Westland, and Pink Kafir with corn when full-fed with silage, cottonseed cake and mineral supplement to yearling steers to fatten them for market. The value of these grain sorghums to western Kansas agriculture is very significant because the grain yield on the average is double that of corn. In order to always have uniform cattle of similar grade and quality to put into the feed lots for these experiments, the Station maintains a Hereford cow herd of 144 cows. The calves and yearlings from these cows constitute the cattle from which the selections are made for the feed lots.

Beef Cattle Grazing Investigations—This is the most recent work established at the Station and comes into fruition as a result of funds made available at the last legislative session for this particular purpose. A start has been made with Mr. Frank B. Kessler in charge of the work. These investigations will be enlarged upon as rapidly as more grazing land can be made available.

State Forest Nursery — This branch of the Station's service is mostly devoted to the produc-

tion and distribution of seedling evergreen and hardwood trees adapted to this area, for the planting of windbreaks, shelter belts and woodlots. Distribution is made in co-operation with the U. S. Forest Service under the Clarke-McNary Act. The highest distribution in one season has exceeded over 500,000 seedlings, and it is anticipated that these numbers will be greatly increased in a short time.

An experimental test block of many trees and shrubs is maintained. Many of them are new introductions by the U. S. Department of Agriculture. Some are new developments by horticulturists of this country. Variety tests of several garden crops are also conducted.

Pure Seed Distribution—The production and distribution of pure, certified seed to farmers of Kansas is one of the most valuable services rendered by the Hays Station. The farmers are very appreciative of a source of foundation seed stock of the best adapted varieties of the most valuable crops grown in this area and, during the past biennium, broke all records in seed purchase at this Station.

The 1945 seed sales exceeded 851,000 pounds, over half of which was sorghum seed; seed wheat sales, 355,000 pounds; Buffalo grass, 6,400 pounds; and other grass seed, 3,500 pounds.

In 1946, seed sales were the highest on record amounting to 960,000 pounds, of which 552,300 were the new Comanche wheat. Sorghums exceeded 386,200 pounds; Buffalo grass, 5,000 pounds; Side Oat Grama, 2,500 pounds; and Buffalo alfalfa seed, the new wilt-resistant alfalfa, 12,900 pounds.

The Last Trek of the Indians, Grant Foreman (University of Chicago Press, 1946, 382 pages, $4.00) is a book that includes within its covers, a good deal of Kansas history. It is, however, largely Kansas history of territorial and pre-territorial days for it considers the great movement —forced migration—of native Americans from their homes to reservations in what now constitute present Kansas and Oklahoma. The migration of the Five Civilized Tribes (the Cherokee, Creek, Choctaw, Chickasaw, and Seminole) from southeastern United States to the territory of present Oklahoma has been traced by Mr. Foreman in a previous book, *Indian Removal.* In the present volume the remaining Indian migrations as the white man gradually forced the Indian westward, are dealt with in detail. The book is not easy reading for the reason that many tribes and many migrations, of necessity, have had to be considered. One can gain some idea of the complexity of Mr. Foreman's problem by simple enumeration of Indian tribes which, at one time or another between 1829 and 1877, have been assigned or have held reservation in present Kansas — Shawnee, Delaware, Kickapoo, Kaskaskia, Peoria, Piankashaw, Wea, Wyandot, Miami, Sauk and Fox, Munsee, Potawatami, Ottawa, "New York", Quapaw, Seneca, Cheyenne, Kansas, Osage, Arapaho, Wichita, and probably others. Some, to be sure, were indigenous, but most were emigrants

from the east, who, after sojourning for a time in Kansas, were eventually removed to Indian Territory.

In many cases, the terms under which the several Indian tribes made treaty with the United States and agreed to the Kansas migration included a familiar guaranty that their new home was to be "their permanent place of residence as long as they remain a tribe." But the onward rush of civilization brooked no treaty as "permanent." Although Kansas was but a temporary stopping place in the last trek of the red man, an examination of the names of Indian tribes enumerated above will show that if the Indian movement had no other effect on Kansas history, it, at least, contributed place names to many towns, streams, and counties of present Kansas.

Dr. W. H. Schoewe of the Academy Committee on Conservation and Ecology recently visited the site of the geographical center of the United States which is located in the SE¼, sec. 32, T. 2 S., R. 11 W. about 1 mile west and 1 mile north of the northwest corner of Lebanon in Smith County. Dr. Schoewe reports that between August 17 and October 9, 1946, visitors from 19 states, Canada and Washington, D. C. had recorded their presence in the registration book kept at the monument or shaft erected by the Hub Club of Lebanon. States included in the list extend from the Atlantic sea board to the Pacific coast line and from the Gulf of Mexico to the International boundary between the United States and Canada and include the following states: Arkansas, California, Colorado, Illinois, Iowa, Kansas, Louisiana, Massachusetts, Michigan, Missouri, Nebraska, New Jersey, North Dakota, Oregon, Texas, Washington, Wisconsin, and Wyoming. The registration book also lists 191 entries between the two dates mentioned. According to Mr. R. R. Wilson of Lebanon over 7,000 entries have been recorded in the register kept at the marker since its erection in 1941. Recorded names are those of visitors from every state in the Union and some from foreign countries.

The spot marking the exact location of the geographical center of the United States had been lost and was unknown for many years. It therefore will be of interest to Academy members to know that this spot has again been found and has been reestablished through the efforts of the Kansas Academy of Science. The project to relocate the center was undertaken by the Hub Club of Lebanon in 1940 after the Academy's committee on conservation and ecology had pointed out to the club the advantages of having this important spot made known.

There is but one geographical center of the United States. Kansas has it; no other state can possess it. Is it not therefore fitting that this spot marking the geographical center of the United States be designated as a National Monument?

Dr. A. B. Cardwell was elected president of the local chapter of Sigma Xi, honorary research

organization, Kansas State College, Manhattan, at a recent meeting of the chapter. Other officers elected were Professors J. A. Shellenberger, vice-president, H. C. Fryer, secretary, and F. C. Gates, treasurer.

The Manhattan chapter of Sigma Xi, honorary research society, has offered a $25 research award to be given annually for the best original research by a graduate or undergraduate submitted for consideration during each year. Each department is entitled to nominate one candidate for the award.

Mr. Earl K. Nixon has been appointed oil and gas geologist on the staff of the State Geological Survey, University of Kansas. Mr. Nixon received his bachelor's degree in geology from the University of Wisconsin and since that time has had extensive professional experience in Minnesota, Michigan, Oregon, the Yukon and South America. Since 1945, he has been in charge of iron ore development in the Orinoco river valley, Venezuela, for a subsidiary of the United States Steel Corporation.

California Agriculture, a 450-page book published in 1946 by the University of California Press as part of the celebration of the seventy-fifth anniversary of the founding of the university, is of interest to anybody concerned with agriculture or with the application of science to agriculture. The book includes an excellent summary of the history of agriculture in California and informative chapters on livestock production, the rich pattern of California crops, protecting plants from their enemies, the soil resources of the state and, of special interest and significance, the economic and social structure of California agriculture. Edited by Dean C. B. Hutchison of the University of California College of Agriculture, the book was written by members of the faculty of that college. As California has long been and still is a testing ground for much that is new in the use of science in the production, storage, transportation, processing and marketing of farm commodities and for various methods of dealing with acute rural social and economic problems, the book should have a wide appeal. The $5 retail price seems too good to be true in view of current costs and of the size and high quality of the book.—F.D.F.

Glimpses From Resource-Full Kansas, a most interesting booklet of 40 pages, has recently been prepared by John C. Frye, John M. Jewett and Walter H. Schoewe. With decorative illustrations, diagrams and a state map, the scenery, rocks, fossils, and industrial minerals and mineral fuels of the state are entertainingly described. If you would know your state—a theme we have been preaching in the *Transactions* now for several years — obtain and read this booklet. Copies may be secured by addressing the State Geological Survey of Kansas, University of Kansas, Lawrence.

The First Hundred Years of the Smithsonian Institution, Webster P. True (Washington, August 10, 1946, 64 pages) is a beautifully and plentifully illustrated brochure which recounts the many activities and progress of this famous and popular American institution during the first century of its existence. Established by the bequest of an Englishman, James Smithson, "for the increase and diffusion of knowledge among men", the Institution, under its first secretary, Joseph Henry, began the fulfillment of the bequest by publishing *Ancient Monuments of the Mississippi Valley* by Squier and Davis, still a standard reference work for archeologists. If diffusion of knowledge was begun by this initial venture of the Smithsonian, increase in konwledge as a function of the Institution was begun by Henry in a meteorological investigation that can be regarded as the forerunner of the present U. S. Weather Bureau. With publication and research set as the goals of accomplishing Smithson's goal, the Institution has grown until it now includes in its bureaus and departments such various enterprises as the National Museum, the Bureau of American Ethnology, the Astrophysical Laboratory (for systematic measurement of the sun's radiation), the National Zoological Park, and the National Gallery of Art and other art collections.

In its hundred years of existence the Smithsonian Institution has played a vital part in American science, and the Kansas Academy of Science can "point with pride" to the fact that one of its members, Dr. Alexander Wetmore, is the present secretary of this national institution.

A Surgeon in Wartime China, Lyle S. Powell (University of Kansas Press, 1946, 233 pages, $2.50) recounts in an interesting manner the personal experiences of a Kansas physician during that phase of World War II when the Japanese made their greatest inroads into China. That our ally as a people were well liked by Dr. Powell is clearly apparent. "I knew them to be good-humored, gracious, kind, and appreciative", he writes. "I knew them to be essentially a gentle people, of mild manner and smiling countenance, a people who could joke at adversity." And of adversity, the Chinese had their share and more, as becomes all too apparent as Dr. Powell's tale unfolds. Not that his story becomes gruesome for few medical technicalities are included. In fact, the military aspects of the Chinese situation at various times are dealt with more technically than is any other phase of the book. A wealth of intimate detail of daily living and daily contact with the Chinese and the Chinese mind, however, make the book an enjoyable one.

In form and typography, Dr. Powell's book is a distinct improvement on any of its predecessors issued by the newly organized University of Kansas Press. Considering the nature of the book, more and better illustrations would have enhanced its interest. The illustrations that

are used, for some curious reason, have been confined chiefly to the last third of the book.

The Thirty-Fourth Biennial Report of Kansas State Board of Agriculture 1943-1944, released during the past fall, is now available for distribution. Copies may be secured by addressing Mr. J. C. Mohler, Secretary, Kansas State Board of Agriculture, Topeka. This 496 page report contains statistical records, by counties and by summary tables, of Kansas agriculture for the years 1943 and 1944. Wheat production in Kansas in 1944, for example, totaled some 192,000,000 bushels, a record which has been exceeded only in two years, 1931 and 1942. The average price of wheat in 1944 was $1.42 a bushel, a value considerably exceeded during World War I when the record price of $2.15 a bushel was reached in 1919. Many other interesting comparisons can be made by examination of this volume, which, with its predecessors since 1872, has come to be a standard reference work. The editor has a fairly complete set of these reports and has found them indispensable for many purposes. In addition to statistical records, they contain special papers on many topics of general Kansas interest. Included in the present volume, among others, are articles on rural welfare, home economics and pioneers in Kansas agriculture. We are pleased to note that Dean L. E. Call's "The Crop Industries of Kansas", which originally appeared in the first quarterly issue of these *Transactions*, has been included among these papers.

There Is No Other Choice

War in the twentieth century has grown steadily more barbarous, more destructive, more debased in all its aspects. Now, with the release of atomic energy, man's ability to destroy himself is very nearly complete. The bombs dropped on Hiroshima and Nagasaki ended a war. They also made it wholly clear that we must never have another war. This is the lesson men and leaders everywhere must learn and I believe that when they learn it they will find a way to lasting peace. There is no other choice.—Henry L. Stimson, *Harper's Magazine*, February, 1947.

A Survey of the Fossil Vertebrates of Kansas
Part III: The Reptiles

H. H. LANE
University of Kansas, Lawrence.

The Class Reptilia follows the Amphibia in the sequence of development among the tetrapods. The reptiles are *poikilothermous, i.e.,* without a mechanism for the control of the body-temperature which changes more or less with the temperature of the surrounding medium. They are always covered with dermal scales, scutes, or bony plates, and are terrestrial or aquatic with an exclusively pulmonary mode of respiration. The heart has two auricles and generally one incompletely divided ventricle (two ventricles in the Crocodilia and probably also in some of the extinct forms), and two systemic aortic arches. The skeleton is completely ossified. The embryo develops directly, *i.e.,* without a metamorphosis, while enclosed in an amnotic sac, and is provided with an allantois. The occipital region of the skull has generally an unpaired condyle for articulation with the anterior end of the backbone. In general the body is elongate and cylindrical.

The reptiles arose as an offshoot of the embolomerous stegocephalians (see this Survey, Part II, *Trans. Kans. Acad. Sci.,* Vol. 48, No. 3, Dec., 1945, page 294) at or before the middle of the Pennsylvanian period, for the fossil remains of well-defined reptiles have been recovered from deposits of this age in Ohio, Illinois and Kansas. Soon the land surface of the earth became the scene of a marvelous deployment of reptilian hosts into every available habitat, and some of them even returned to live in the sea. These changes in habit were not sudden, for the reptiles evolved through the slow accumulation of slight variations, during Carboniferous times—an interval of millions of years—when both they and the contemporary amphibians were changing in many ways, though still retaining to a greater or less extent in specific cases the old ancestral traits, modifying or replacing them as made necessary by new conditions of life.

In short, from their first appearance the reptiles steadily advanced in structure and in adaptation to varied habitats, producing before the close of the Paleozoic some of the most bizarre forms of vertebrates the world has even seen. These highly specialized and probably prematurely senescent reptiles did not survive the close of the Permian period, for the Triassic opened with relatively few

Transactions Kansas Academy of Science, Volume 49, No. 3, 1946.

saurians, and these were mostly primitive, generalized types. But from these survivors there arose rather quickly many diverse lines of adaptation in consequence of which, throughout the whole Mesozoic Era, the reptiles were in their heyday, dominating the land, conquering the air, and invading the sea. They grew from forms whose length can be measured only in inches to some that were the largest animals ever to walk on dry land, approaching a hundred feet in length and weighing up to forty tons or more. However, huge size goeth before extinction, and the Cenozoic Era began with only a pitiful remnant of this class, namely, turtles and tortoises—even then of very ancient lineage—, lizards, snakes, crocodiles and their ilk, and lastly, but most interesting of all, the lone *Sphenodon* of New Zealand, truly a "living fossil", for all its near relatives lived in other parts of the world and became extinct in the Mesozoic.

As we have shown, the amphibians, which were the direct offspring of crossopterygian fishes, have retained so many ancestral characteristics that they have never become completely emancipated from the water. Hence the amphibians as a class have never been able to occupy dry land far away from the water's edge. But that is just what their more progressive offspring, the reptiles, succeeded in doing. Of course, no reptile, nor any other animal, can long remain active, or even live, without water. But the reptile learned how to provide moisture or to conserve it when on the driest land, *e.g.*, on a desert; and in so doing, unconsciously of course, yet in a most ingenious manner, solved some very difficult problems which no amphibian had ever learned to do.

Among these problems is that of desiccation. A frog confined in a dry room at a temperature of 80° to 90° Fahrenheit soon dries up and mummifies, despite the mucous glands in its skin, the function of which is to slow down evaporation of the body fluids through the skin and thus to delay or to prevent desiccation. Such an ineffective device is not sufficient to preserve life on really dry land, so the reptiles did away with these mucous glands entirely (hence, contrary to popular impression, *no reptile is "slimy"*) and covered their bodies, head, tail and limbs with horny scutes or scales to conserve the body fluids.

Yet an even more difficult problem lay in the necessity to produce an egg that could be deposited in dry sand or soil. Obviously, a jelly-coated egg like that of an amphibian is not adapted to such a situation. Its moisture content would quickly evaporate and the embryo would die. Such fatal desiccation is prevented by the en-

closure of the reptile egg in a semi-porous leathery or limy shell. This reduces the evaporation of its contained moisture to a minimum, while at the same time the shell is porous enough to permit slow diffusion of air through it. To further protect the embryo, there is put within the shell a large amount of albumen, food for the embryo as it grows in size and needs more room. Still more food to meet the requirements of the embryo is provided by the storage of yolk (largely lecithin) in a yolk-sac, an organ connected with the embryonic mid-gut. Then there was the further problem of a water-supply to satisfy the needs of the living, growing embryo. As the solution to this problem the reptilian egg contains a surprisingly ingenious device, for within it there is an *aquarium* (*amnion*) *full of water* in which the embryo is immersed and in which it lives like a fish or amphibian tadpole!

The reptilian embryo, being a living organism, not only needs food and water, it must also have oxygen for respiration and it produces carbonic acid gas, a waste to be gotten rid of. So, there was developed another important device within the egg, namely, a sac whose walls are richly supplied with fine blood-vessels. This sac grows out from the hind-gut of the embryo until it flattens itself against the inner lining of the shell. In this favorable position it can absorb air through the shell and give off its waste carbonic acid gas to the outside world. As just noted, this respiratory device (*allantois*) is a *sac;* for purposes of respiration it could just as well have been a mere flap of vascularized tissue; but it is also utilized for another purpose. The living embryo has other waste products—liquid or solid—to be gotten rid of. Obviously such wastes cannot be passed out through the shell, but must be stored up within it until the creature hatches. This necessity was met by the development of a *cess-pool* or *septic-tank, i.e.,* this allantoic sac, a structure discovered and named by Aristotle in the fourth century B.C.; he likewise discovered and named the amnion, or aquarium, mentioned above. As the result of all these devices the reptile can lay its eggs and produce its young on dry land.

Relations of Reptiles to Amphibians

Living amphibians and reptiles are distinguished by so many characters, superficial as well as deep-seated, that no zoölogist is ever in doubt with a specimen of either in hand. But fossil forms reduce the gap between these two groups to such an extent that it is sometimes very difficult or even impossible to assign a specimen definitely to the one or other group. A notable example is seen in

Seymouria, a Permian genus known in great, almost complete detail, yet those most intimately familiar with it are divided in their conclusions—to some it is a highly specialized reptile-like amphibian; to others it is a very generalized reptile that still retains many amphibian-like characteristics.

The most decisive criterion that would distinguish *all* amphibians from *all* reptiles is the universal occurrence in the former, but never in the latter, of an abrupt *metamorphosis* or change of form from an aquatic into a more or less terrestrial stage. But obviously this is a criterion that is not often easy to apply in the case of *fossil* species. In many of the extinct, so-called Amphibia the existence of a metamorphosis in their life-history is only a matter of inference because of their close anatomical resemblance to other forms in which a metamorphosis is known to occur. The paleontologist is, therefore, dependent ordinarily wholly upon discernible differences in the skeleton in making this distinction.

Formerly the most important anatomical character for this purpose was thought to lie in the form, size and relations of the bones of the palatal region of the skull, where in the amphibian a large *parasphenoid* extends forward *to* or *nearly to* the prevomers and *between* the two pterygoids which are generally widely separated by it. In the typical reptiles, on the other hand, the parasphenoid is much smaller in size relative to the adjacent elements; does not reach nearly to the prevomers anteriorly; but is crowded backward and reduced by the encroachment upon it of the enlarged pterygoids which meet in the median line in front of it. A *pair* of occipital condyles serves to articulate the skull with the anterior end of the backbone in all amphibians since the beginning of the Mesozoic.

But it is now known that the *earliest* amphibians had the *closed* palate of the earliest reptiles, and they had only a *single* occipital condyle. In other words, the open palate with the elongated parasphenoid was a later acquisition of the amphibians, and was *not* distinctive of the *earlier* species, and the same is true of the double (paired) condyles. The ancestral crossopterygians handed down only a *single* condyle to their amphibian children and reptilian grandchildren; the former had, in general, acquired paired condyles before the close of the Pennsylvanian, there being in fact but one known Permian amphibian with only a single condyle. But the reptiles retained the unpaired condyle until much later; many, indeed, have never lost it, though some of the cynodonts developed two condyles shortly before they underwent their evolution into mammals.

The amphibians seem never to have had as many bones (*phalanges*) in the fingers and toes as are found in the early reptiles; while, in contrast, no reptile is known to have had as many elements in the ankle (*tarsus*) as the early amphibians. But, as Williston long ago remarked, there is no doubt that the feet of the earliest reptiles, when discovered, will be found to be no different from the feet of the contemporary amphibians.

The immediate effect of the adaptive changes effected by the reptiles was to give them such advantages over the amphibians in the struggle for existence that they quickly became dominant on the land and were able to occupy every possible sort of terrestrial habitat, where they had no significant competition except among themselves. The marvelous diversification of the reptiles, first in the Permian, later throughout the greater part of the Mesozoic Era, was due to these and various other adaptations. When the land areas no longer afforded sufficient room for their further increase, many of them re-entered the waters and long successfully maintained their supremacy in river, lake and sea over the fishes and amphibians. At last, a few found their way into the air and became efficient flying machines, doubtless holding in check for ages the eventual supremacy of the birds in that medium.

The following table gives in an abbreviated form an outline classification of the Reptilia sufficient for our purpose here. It omits a number of orders and subordinate groups with which we are not directly concerned in this survey.

CLASSIFICATION OF THE REPTILIA

SUPERCLASS TETRAPODA
- CLASS REPTILIA
  - SUBCLASS ANAPSIDA
    - Order 1. Cotylosauria*
    - Order 2. Eunotosauria*
    - Order 3. Chelonia
      - *Suborder a. Amphichelydia**
      - *Suborder b. Pleurodira*
      - *Suborder c. Cryptodira*
      - *Suborder d. Trionychoidea*
  - SUBCLASS SYNAPSIDA*
    - Order 4. Pelycosauria*
    - Order 5. Therapsida*
  - SUBCLASS EURYAPSIDA*
    - Order 6. Protorosauria*
    - Order 7. Sauropterygia*
      - *Suborder a. Nothosauria**
      - *Suborder b. Plesiosauria**
    - Order 8. Mesosauria* (=Proganosauria*)
  - SUBCLASS ICHTHYOPTERYGIA*
    - Order 9. Ichthyosauria*

*Wholly extinct.

SUBCLASS LEPIDOSAURIA (=DIAPSIDA)
Order 10. Eosuchia*
Order 11. Rhynchocephalia
Order 12. Squamata
Suborder a. Sauria
*Suborder b. Mosasauria**
Suborder c. Serpentes (=Ophidia)
SUBCLASS ARCHOSAURIA
Order 13. Thecodontia* (incl. Phytosauria*)
Order 14. Crocodilia
Order 15. Saurischia*
*Suborder a. Theropoda**
*Suborder b. Sauropoda**
Order 16. Ornithischia*
*Suborder a. Ornithopoda**
*Suborder b. Stegosauria**
*Suborder c. Ankylosauria**
*Suborder d. Ceratopsia**
Order 17. Pterosauria* (=Pterodactyla*)

The Subclass Anapsida (from the Greek, meaning "without openings") is the oldest and most primitive division of the Reptilia. The members of this group are often called "stem" reptiles since they were the fount from which flowed the later adaptive radiations so pronounced in this class, first in the late Paleozoic and again in the Mesozoic. The anapsidans resemble the stegocephalian amphibians in having the temporal region of the skull wholly roofed over, or at most secondarily notched from the side, never perforated as in later sub-classes. Three orders of anapsidans are recognized, viz., the Cotylosauria, the Eunotosauria, and the Chelonia—the first two long since extinct, the last alone with living representatives.

In the Cotylosaurs there is a large *parietal foramen* to accommodate the third eye, and the nostrils are separate. The teeth are either conical or transversely elongated and cusped, in one or more rows upon the jaws. The skeleton throughout is primitive. The vertebrae are deeply biconcave (*amphicoelous*), often with a persistent notochord; sacral vertebrae are generally *two* in number. Both shoulder and pelvic girdles in the adults usually have their several elements fused together. Both the front and hind feet are five-toed, stubby and compact, with the phalangeal formula 2-3-4-5-3(4). Some of the most typical genera are only doubtfully distinguishable from embolomerous stegocephalians and were probably the root-stock from which, directly or indirectly, all the later types of reptiles arose. Ranging from one to ten feet, or more, in length, they varied greatly in size as well as in structure and habits. They were semi-aquatic, or marsh-dwelling, or lowland forms, never running speedily nor climbing. The body and legs were generally short and stout,

*Wholly extinct.

never long and slender; the neck was always short. Probably the body was covered with horny epidermal plates or scutes, rarely with dermal ossifications. The earliest known member of the order (*Eosauravus*) was thus named by Williston and dates from the middle Pennsylvanian of Ohio; the latest are from the middle Triassic. None has been found in Kansas.

The members of the second order, Eunotosauria, appear to have been directly ancestral to the turtles and tortoises, and are intermediate in structure between them and the cotylosaurs. Unlike the chelonians, but certainly to be expected in their ancestors, the Eunotosauria had teeth on the premaxillae, maxillae and palatines. Only a single species, *Eunotosaurus africanus* Seeley, from the middle Permian of South Africa, is known; its age fits very well into the hypothesis of its relationship to the chelonians since the earliest known member of the latter group is from the Triassic.

The Order Chelonia, sometimes known as the Testudinata, has the skull completely roofed over as in the cotylosaurs, but, unlike the latter, the temporal region is usually exposed by emargination of the roofing bones; while the supratemporal, dermsupraoccipital and tabulars, present in the cotylosaurs, are absent in the chelonians. The body is more or less completely enclosed in an armor of bone comprising a *carapace* above and a *plastron*, or "breast-plate", below. While the phalangeal formula in the cotylosaurs is usually 2-3-4-5-3 (4), in the Chelonia it is always reduced to 2-3-3-3-3, or even to 2-2-2-2-2 or less in some cases.

Were we not familiar with chelonians from early childhood, and were they very rare or even known only from fossil specimens, they certainly would excite in us greater interest than perhaps any other group of vertebrates. For, this is the only sort of animal that can, for safety's sake, withdraw its head, legs and tail to a position *inside* its ribs. Hence, no other order of reptiles is so distinctly marked off from all the others. As far back as their history is known (to the Triassic) their jaws are inclosed in a horny beak and only in the genus *Stegochelys* of the Triassic is there any trace of teeth on the jaws,* though the upper Triassic genus *Triassochelys* had small teeth on the vomer and parasphenoid in the roof of the mouth, but none on the jaws themselves. Unlike more recent chelonians, the short neck of *Triassochelys* was not retractile, so that the head could not be pulled back under the carapace for protection.

*Tooth-germs have been reported in embryos of *Trionyx*, a soft-shelled turtle living in fresh water, but they never cut the gum, nor in fact are they ever more than mere rudiments of teeth.

Four suborders of chelonians are generally recognized, of which the first, the Amphichelydia, with a short, non-retractile neck, biconcave vertebrae, a pelvis not united with the shell, and certain additional minor technical differences in the skull and the arrangement of the plates of the under shell (*plastron*), lived from the upper Triassic to the Eocene in North America and Europe. Here belongs the genus *Triassochelys* with its toothed palate. From Kansas, Cragin reported a member of this suborder under the name of *Desmatochelys.* While in fact the type specimen (KUMVP, No. 1200) came from Fairbury, Neb., but near the Kansas line, in the Benton Cretaceous, later specimens were actually found in this state. Williston described and named the type *Desmatochelys lowii.* The skull greatly resembles that of such *living* sea-turtles as *Chelone,* the Green Turtle, although with some conspicuous differences. The vertebrae of *Desmatochelys* even suggest pleurodiran affinities. The skull is over eight inches long, nearly six inches wide across the quadrates, and almost four inches high. The mandible is over six inches long. The carapace is narrow in proportion to its length and is pointed behind, *i.e.,* rather heart-shaped. Its plastron seems to have been somewhat similar to that of *Protosphargis,* a fossil relative of the living marine Leatherback Turtle. There are, however, apparently no living representatives of the suborder Amphichelydia.

The second suborder, the *Pleurodira,* has no teeth and the head is withdrawn by being turned to the right or left to lie between the margins of the carapace and plastron. Found now largely if not wholly in the southern hemisphere, they formerly occurred in Europe and North America in Cretaceous and Eocene times, though no representative has been recorded in Kansas.

The third suborder, the *Cryptodira,* includes the greater number of chelonian species both living and fossil. They have the carapace covered with horny scutes; the neck bends in a vertical S-curve if retractile; and the pelvis is not fused to the carapace or plastron. Of the six families usually recognized, two are represented in Kansas by fossil species. The first of these is that of the *Chelydridae,* which includes the notorious living Snapping Turtle (*Chelydra serpentina*) and, among the fossil forms, *Protochelys laticeps,* described by Williston in 1900. The type of this genus and species (KUMVP, No. 1204) was collected by E. H. Sellards and J. T. Shearer from the Niobrara Cretaceous, on the Saline River in Trego County. The skull is about 4½ inches long by approximately the same width across the quadrates. In shape, the carapace is broad and only

little pointed behind. As preserved it is rather flat, being only slightly convex above, possibly as the result of pressure while undergoing fossilization. It is about 30 inches long in the mid-dorsal line and 29 inches across the broadest part. The dorsal surface is mostly smooth and differs from that in almost all its allies of the Cretaceous in being almost completely ossified.

Another family of cryptodires with fossil representatives in Kansas, is that of the *Cheloniidae,* a group of sea-turtles that ranged in time from the upper Cretaceous to the Miocene in North America, and to the Recent in Europe. Here belongs the much-esteemed Green Turtle (*Chelone mydas*) whose range in time extends from the Oligocene to the present in European waters. At least five genera of fossil turtles from Kansas have been ascribed to this family, though such a position for two or three of them may be questioned. The other two are giants among American turtles, viz., *Archelon* and *Protostega.*

The living Green Turtle (*Chelone mydas*) is a miniature of these old sea-turtles of the Cretaceous, which sometimes reached a length of 12 feet. The bony parts of their carapace were greatly reduced and the weight, thus lightened, was largely supported by the water. Since they probably had few or no marine enemies large enough to menace them seriously, the reduction in their armor could be safely made. Moreover, as they were strictly marine, and probably never came ashore except to lay their eggs, their limbs, especially the front ones, were modified into powerful paddles with broad, elongated webbed fingers without claws, by which they rowed themselves like a boat through the water.

Archelon, first described by Wieland, comprised several species all of which lived in the great inland Cretaceous sea that crossed Kansas. The largest of these must have weighed, in life, three tons or more. They had a flat body and a short, non-retractile neck. The jaws were covered with a horny beak which was drawn out in front into a formidable hook. The rami of the lower jaw fused together *only late in life.*

Protostega, first described by Cope, was in size and general build very much like *Archelon,* and also comes from the upper Cretaceous of Kansas (KUMVP, Nos. 976, 986 and 2212). The top of its upper jaws was furnished with a hooked beak, but shorter than that of *Archelon.* The rami of the lower jaw fused together *very early in life.*

Another genus of sea-turtle from the Cretaceous of Kansas is *Toxochelys,* comparable to the living *Cheloniidae,* though sometimes

assigned to a family of its own, the *Toxochelydae*. *Toxochelys* is very similar in form to the genera *Chelone* and *Thalassochelys,* having a low flat head, roofed over behind by the same bones of the skull, and provided with the large sockets for the eyes characteristic of the *Cheloniidae*. Its limbs are long powerful flippers. *Toxochelys serrifer* Cope, the smallest described species, was only about two feet in length, while *T. latiremis* Cope, the largest known species, reached a length in old individuals of six feet. Still another species, *T. brachyrhinus* (type: KUMVP, No. 1212), was described by Case from material in the University of Kansas Museum of Natural History. In this species the individual bones of the skull are very similar to those in *T. latiremis* Cope, but the proportions of the whole skull are very different. "Instead of the broad posterior end rapidly contracting anteriorly, the sides are much more nearly parallel, and the anterior end, instead of terminating in a sharp nose, with much divergent maxillaries, is so blunt as to give an almost square appearance. The quadrates are nearly equal in height to those . . . of *T. latiremis,* though the skull is shorter and much narrower. The upper surface of the roofing bones shows a strong sculpture of deep pits and rugose lines, not observed in . . . other species" (Case). The type of *Toxochelys stenoporus* is also in the University of Kansas Museum (No. 2060).

In 1872 Cope described another fossil turtle, *Cynocercus incisus,* probably from the Niobrara Cretaceous of Kansas, but the type consists of such fragmentary material that little more can be said definitely about it other than that it appears to be related to *Toxochelys*.

The cryptodiran family *Testudinidae* includes the great majority of our land and river tortoises and terrapins living today. They have been represented in North America and Asia since the upper Cretaceous, and in Europe since the Eocene. One of our old genera is *Testudo,* that has lived in North America since the Oligocene, but is known to be represented in Kansas only since the middle Pliocene. The type of *Testudo gilbertii* Hay (KUMVP, No. 1245) is from Long Island, Phillips County, Kansas, while specimens (but not the type) of *T. nebrascensis* (KUMVP, Nos. 1250-51) are also in the K.U. Museum of Natural History from Logan County. *Testudo diamondi* (KUMVP, No. 1252) may have come from the same locality. In 1944, Dr. C. W. Hibbard reported a fossil land tortoise under the name *Testudo riggsi* from the Saw Rock Canyon fauna, middle Pliocene of Seward County, Kansas. The type (KUMVP,

No. 6789) consists of a nearly complete carapace and plastron, evidently of a mature individual several years of age. A second specimen (KUMVP, No. 6790) probably represents the female, while the type seems to have been a male. This is probably the smallest known fossil species of *Testudo* from North America.

The *Trionychoidea,* the last suborder, and in many respects the most highly specialized of the Chelonia, comprises the "soft-shelled" turtles of our rivers and lakes. No fossil representative has been recorded from Kansas. Several other species of fossil turtles have been described from Kansas, but were based upon such fragmentary material as to be indeterminable now; hence they are omitted from our discussion.

The SUBCLASS SYNAPSIDA, while comprising mostly generalized reptiles, was nevertheless not so primitive as the Anapsidans, from which they had obviously descended. The most characteristic specialization in the synapsids was the development of a single temporal opening in the skull. This opening varies much in size but is always bounded above by the postorbital and squamosal bones. In other words, the completely roofed-over skull of the cotylosaurs had given place to one with a hole through its roof!

Two orders are recognized among the synapsids, both extinct, one American and European, the other South African and Asiatic in distribution. These are known respectively as the *Pelycosauria* and the *Therapsida.* The latter is of supreme interest in connection with the problem of the origin of the mammals, but no representative of this order is known from North America. The other order, the *Pelycosauria,* on the contrary, is not only characteristically North American but has yielded at least two fossil representatives from Kansas.

The *Order Pelycosauria* is composed of reptiles that were still as primitive as many of the cotylosaurs in most of their skeletal characters. Their vertebrae were deeply biconcave (*amphicoelous*) and always included an *intercentrum.* Their limbs were primitive with the humeral (upper arm) and femoral (thigh) portions carried in a horizontal position, which gave these animals a sprawling posture and a waddling gait. They constitute a more diversified group than the cotylosaurs from which they differ *constantly* only in respect to the temporal perforation in the skull, a decidedly longer neck and usually longer and more slender legs. The pelvis is plate-like and lacks a foramen. They were apparently carnivorous, malacophagous, insectivorous, or vegetarian in diet, in different cases.

FIG. 1.—From a photograph by D'Ambra of a diorama in Dyche Museum showing two types of Pelycosauria: Dimetrodon in the center and at the left; and Edaphosaurus at the right foreground. Diorama composed by Mr. Bernard Frazer under the author's direction.

While the earliest pelycosaur appeared in the middle Pennsylvanian, it was in the Permian that they produced some of the most bizarre forms yet to appear among all the reptiles. These were the so-called "fin-backed lizards" in which the spinous processes of the vertebrae in the neck, trunk and anterior part of the tail were more or less elongated, in some instances reaching 2½ to 3 feet in height. Without doubt these long processes supported a dorsal "fin" or "sail" of skin, and probably other tissues as well, which could never be furled since there was no joint at the base of the spines. Some of these creatures, like *Dimetrodon* (Fig. 1), reached a length of eleven feet, and the sail was more than half that long and at its apex was nearly or quite three feet high. What the function of such an organ could have been is not at all clear and despite several suggestions one can only look at it in wonder. Evidently it was of no survival value for all possessing such a sail were extinct by the middle of the Permian.

Discoveries of pelycosaurs in Kansas must always be rare, since the Permo-Carboniferous deposits in this state are mostly marine. Only such as met death close by the sea-side and whose remains had a chance to be carried down by a stream to salt-water, are therefore likely to be found. Yet at least three authentic pelycosaurian finds have been made in Kansas.*

*The record of *Clepsydrops* from eastern Cowley County by Williston in 1898 was probably an incorrect identification. Since the specimen apparently has been lost no determination is now possible.

The first of these is a single specimen, *Ophiacodon hilli* Romer, 1925, from the Fort Riley Limestone, in Wildcat Canyon, near Winfield, Cowley County. This is an average sized pelycosaur (type: Walker Museum, University of Chicago, No. 454) and is distinguished by Romer from other nearly related species "by the unusual distal breadth of the humerus. . . . The sole specimen is of interest in that it is preserved in a slab of marine limestone. . . . The most remarkable feature is the unusually well-preserved series of ventral ribs, perhaps the most perfect seen in any pelycosaur" (Romer). *Ophiacodon hilli* is comparable in size to the Texas species, *O. uniformis,* which Romer estimates to have weighed over a hundred pounds and to have reached a length of about five feet.

Dunbar, in 1894, reported another pelycosaur, a fragmentary specimen of *Edaphosaurus,* found at Elmo, Dickinson County, in the Wellington formation. *Edaphosaurus* is one of the pelycosaurs with the elongated spinous processes supporting a "sail". In it, however, the spines are not simple as in *Dimetrodon,*† but bear short, peglike cross-bars of various sizes. Hence it has sometimes been referred to as the "telephone pole" reptile. Again, unlike *Dimetrodon,* it had its palate and the inner side of its jaws provided with a number of small teeth. It probably fed on small, soft invertebrates of various sorts. While most pelycosaurs had three sacral vertebrae, *Edaphosaurus* had but two.

The most recently recorded pelycosaur from Kansas is a sphenacodont described by the present writer from the Rock Lake shale member of the Lansing group, Missourian series, Pennsylvanian system, in Anderson County. To this species was given the name *Petrolacosaurus kansensis*‡—i.e., "the Rock Lake reptile of Kansas". The type specimen (KUMVP, No. 1424) is a nearly complete hind limb, with which was associated a nearly complete left half of the pelvis (KUMVP, No. 1425). The limb is about 7½ inches in length, and indicates a lizard-like animal some 2½ to 3 feet long, or possibly even longer. It is, therefore, much smaller than some of the Permian pelycosaurs, such as *Dimetrodon.** Whether it had elongated neural spines like that and other sphenacodonts, cannot be determined in the total absence from the find of all its vertebrae,

†*Dimetrodon* is the large individual shown in the center of Fig. 1; *Edaphosaurus* is the reptile in the lower right hand corner. Photograph of a diorama in the University of Kansas Museum of Natural History, composed under the author's direction by Mr. Bernard Frazier.

‡For a more extended and technical description of *Petrolacosaurus* the reader is referred to the article: "New Mid-Pennsylvanian Reptiles from Kansas," by H. H. Lane, in these *Transactions,* Vol. 47, No. 3, March, 1945, pp. 381-390.

*Some species of *Dimetrodon* have a skull 18 inches in length; they were probably the largest and most powerful, as well as among the most common carnivorous reptiles in the Permian.

but it probably did not have them, since its age is middle Pennsylvanian and the "sail-backs" are known only from the lower Permian. In all probability it was still more generalized, *i.e.*, more nearly like the average pelycosaurian than like the later, bizarre, highly specialized genera such as *Dimetrodon* and *Edaphosaurus*.

The SUBCLASS EURYAPSIDA is characterized by the presence of a single temporal opening which, in contrast to that in the Synapsida, has its *lower* margin inclosed by the postorbital and squamosal, instead of lying *below* these bones. Moreover, the precoracoid is absent from the pectoral girdle. The members of this subclass were mainly aquatic, or at least amphibious, types of the Permian and early Mesozoic. Two orders may be recognized here, the *Protorosauria* and the *Sauropterygia*.

The *Order Protorosauria* was erected provisionally by Williston to include the lower Permian *Araeoscelis* from Texas and the upper Permian *Protorosaurus* of Europe, and a few other rather peculiar genera. Romer assigns to it not only the genera just mentioned, but certain others in addition. The protorosaurs appear to have been an early side branch of the cotylosaurs. Williston characterized the order as consisting of "quadrupedal, arboreal, terrestrial, or subaquatic reptiles one to six feet in length, with a single upper temporal opening between the parietal and the temporal arch, the quadrate fixed. Ribs in part or all single-headed, articulating with centra; a single coracoid, an interclavicle, and clavicles" present (see Williston, Osteology of the Reptiles, p. 259).

The second order of synaptosaurians is that called the *Sauropterygia*, in which the vertebrae have *flat* faces; the ribs are single-headed but articulate with the diapophyses rather than with the vertebral centra; only a single large coracoid on each side; the head or neck is more or less elongated.

To one or the other of these two orders has been assigned the family *Araeoscelidae* by different authors. We are inclined to place it among the Protorosauria, following Williston and Romer. In addition to the genus *Araeoscelis* from the lower Permian of Texas, there is a second, *Podargosaurus*, from the middle Pennsylvanian of Kansas. The species, *Podargosaurus hibbardi* Lane (type: KUMVP, No. 1423) is based on a single specimen consisting of a practically complete *front* limb, with which were associated a second front limb, the crural, tarsal and pedal portions of a hind limb, in obverse and reverse on two slabs of shale, a few trunk vertebrae, a few ribs, and a long series (30 or more) of caudal vertebrae. These

remains all pertain to the same individual, some of the parts mentioned overlying others in the matrix, and all within an area roughly 8x15 inches in extent. The form represents a genus and species not previously known.

This specimen came from the Rock Lake shale member of the Lansing group, Missourian series, Pennsylvanian system, in Anderson County, Kansas. The horizon is assigned by the Kansas State Geological Survey to the *middle* Pennsylvanian. The long slender limbs, the very long tail, almost thread-like at its termination, the single-headed ribs, the humerus with an epicondylar foramen—all these characters are strongly suggestive of the lower Permian *Araeoscelis* described many years ago by Williston. Beyond a shadow of possibility, *Podargosaurus* does not belong either to the cotylosaurs or to the pelycosaurs; its slender build and other resemblances to *Araeoscelis* indicate its inclusion in that family. The age of *Podargosaurus*, middle Pennsylvanian instead of lower Permian, indicates merely that the earlier sauropterygians have not hitherto been found, and that the order originated further back in time than the previous records would lead one to believe.

An important suborder of sauropterygians is that called the *Plesiosauria*, a group that ranged from the Triassic to the close of the Cretaceous, though there is reason to believe that it had representatives as far back as the Permian. They were especially prominent and important elements in the life of the upper Cretaceous sea of Kansas. They were marine reptiles varying in length from about six or eight feet up to fifty or more. Their limbs, both fore and hind, were modified into paddles in which the segments of the fingers and toes were often increased in number. In these reptiles locomotion was not accomplished by the sculling action of a powerful tail, but by the far more laborious method of *rowing* by means of the paddle-like limbs. Because of the relatively slow rate of speed thus possible, the plesiosaurs had to make use of an elongated head or neck to secure their prey, which undoubtedly consisted largely of small fishes, squids, and other small fry.

What Williston wrote in 1903 is largely true today: "There are few orders of reptiles, so long and so widely known as are the plesiosaurs, of which our knowledge is more unsatisfactory." At the date when Williston wrote these words thirty-two species and fifteen genera had been described from the United States, but most of them were based upon such fragmentary material that their certain identification is now impossible. The number of plesiosaur-

ian species described from Kansas is well over a dozen, all from the Cretaceous. Stability and clarity in the classification of this group can never be attained until vastly more material is collected in the field and the types and other specimens already in the museums have been subjected to a thorough, critical analysis.

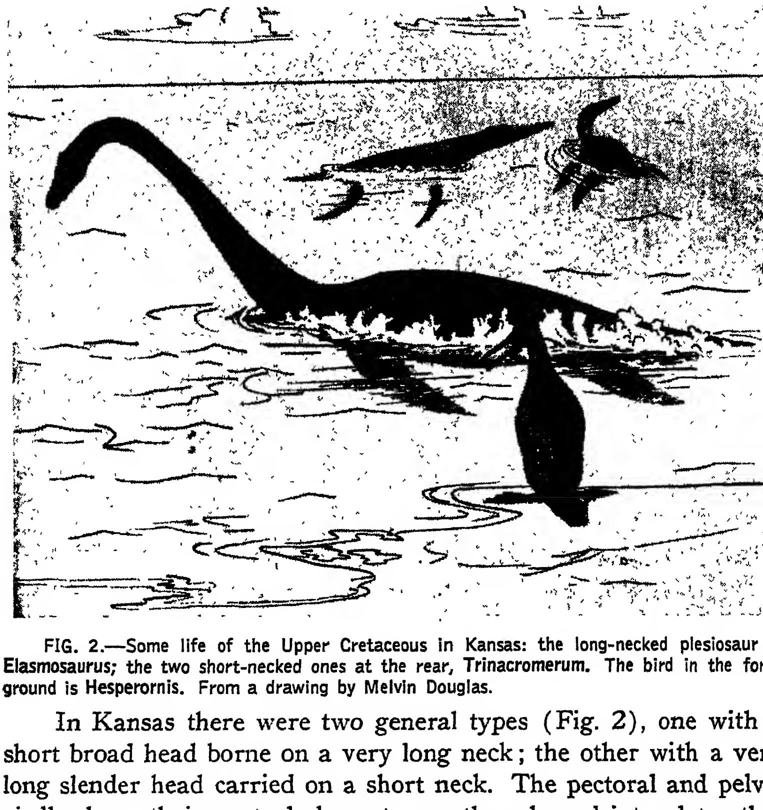


FIG. 2.—Some life of the Upper Cretaceous in Kansas: the long-necked plesiosaur is Elasmosaurus; the two short-necked ones at the rear, Trinacromerum. The bird in the foreground is Hesperornis. From a drawing by Melvin Douglas.

In Kansas there were two general types (Fig. 2), one with a short broad head borne on a very long neck; the other with a very long slender head carried on a short neck. The pectoral and pelvic girdles have their ventral elements greatly enlarged into plates that almost constitute a plastron, or, rather *two,* since they are not continuous throughout the central part of the belly, where a series of parasternal ribs (nine or so in number) occupies the interspace. One striking feature is the great variation in the number of cervical vertebrae, ranging from as few as eleven in the Plesiosauridae to as many as seventy-six in the Elasmosauridae.

One interesting habit of the plesiosaurs, at least of the long-necked forms, was noted long ago by Williston, who commented on their "habit of swallowing siliceous pebbles, sometimes of considerable size and in considerable quantities; as many as a peck have been

found among the remains of a single animal. . . . These pebbles, moreover, were carried in the plesiosaur's stomach until reduced to very small dimensions, indicating clearly the smallness of the pyloric orifice and the complete digestion of the food material." This is certainly circumstantial evidence that the plesiosaurs may have had a gizzard like a chicken. Moreover, these siliceous pebbles are not such as occur anywhere in Kansas. They must have been obtained hundreds of miles away along the coast of the Cretaceous sea bordering the Black Hills of South Dakota; hence it is evident that the plesiosaurs were no mean voyagers.

In common with nearly all aquatic reptiles, the plesiosaurs had a ring of well-developed sclerotic plates in the eyeball which gave protection to the eyes under varying water-pressure, an indication that these animals were in the habit of diving to considerable depths. In common with nearly all the other larger marine vertebrates the bones of the plesiosaurs are soft and spongy, easily broken or crushed, clearly indicating that they were not bottom feeders but captured their prey, diving and pursuing it under water like cormorants or penguins. They were probably not speedy swimmers, for while their bodies were not so broad and flat as those of turtles, yet they were not fashioned along the lines of a swift-swimming fish. Moreover, their paddles were quite small in comparison with the size of the body, and the tail was so small as to be useless as an organ of propulsion. They must have progressed slowly by rowing after the manner of turtles rather than swiftly by the sculling action of the tail, like the mosasaurs and crocodiles.

No evidence of the manner of reproduction in these reptiles has come from our Kansas specimens, though the Old World forms support the idea that they brought forth their young alive. However, leg bones of *embryonic* plesiosaurs have been found several times in Kansas, but not in association with the remains of adults.

The latest classification of the plesiosaurs is that of Dr. T. E. White, of the Museum of Comparative Zoology at Harvard University, who recognizes nine families, largely on the basis of variations in the structure of the shoulder girdle. At least four of the nine families are represented by species recorded from Kansas. The first of these is that called the *Plesiosauridae*. Three species from this state have been more or less provisionally referred to the genus *Plesiosaurus*, although when more fully known one or all may be referred to a different genus. *Plesiosaurus gulo* (type: KUMVP, No. 1329) was described by Cope from the Fort Pierre Cretaceous;

P. mudgei (KUMVP, No. 1305), from the "Comanche (lower) Cretaceous of Kansas", was described by Cragin in 1894; while *P. gouldii* (type in KUMVP, *but not numbered*), likewise from the "Comanche Cretaceous", was described by Williston in 1907. The last species, *P. gouldii*, "is much larger than *P. mudgei* and its dorsal vertebrae differ in the form of the centrum, which is peculiarly heart-shaped. . . . The species is referred to *Plesiosaurus* because no better place for it is known; in all probability it really belongs to some other genus. The species was based upon several dorsal vertebrae in fairly good preservation" (Williston).

The second family of plesiosaurs recorded from Kansas is that of the *Polycotylidae*, established by Williston in 1908. Two genera and six species have been described from remains found in this state. The genus *Polycotylus*, with 26 cervical and 28-29 trunk vertebrae, was erected by Cope for the species *P. latipennis;* the Kansas record rests upon seven or more specimens, the first of which, a complete paddle, is the type (KUMVP, No. 5916) and was found by George A. Allman of Wallace, Kansas, in the upper Niobrara chalk on the Smoky Hill River, east of Fort Wallace. Another specimen (KUMVP, No. 1308) was collected by H. T. Martin, in the Niobrara of Logan County, in 1894; a third (KUMVP, No. 1312) was found by Charles H. Sternberg in 1895, also in the Niobrara of Logan County; the fourth (KUMVP, No. 1316) came from the Benton Cretaceous of Russell County; and four others (KUMVP, Nos. 1320, 1321, 1323 and 1324) came from the Niobrara of Wallace County.

Williston described a second species, *Polycotylus dolichopus,* from Kansas, the type of which is in the Museum of Yale University.

Closely related to *Polycotylus* is Cragin's genus *Trinacromerum* from the upper Cretaceous of Kansas, with its large, long-snouted head, numerous small teeth, and 19 to 23 vertebrae in the neck, which is only slightly longer than the head. There are 30 or fewer trunk vertebrae and 3 sacrals. Cragin's specimen, *T. bentonianum,* was collected in the "Benton Cretaceous", and is characterized by the presence of an interclavicular foramen, previously unknown in plesiosaurs. It shares with *Polycotylus* the presence of an *interpterygoidal vacuity,* anterior to the parasphenoid, unknown in any other reptiles. The slender parasphenoid separates two long narrow openings between the pterygoids, which Williston called the *"parasphenoid vacuities",* though suggesting that they may really be the internal

nares. The name *Trinacromerum* indicates the presence of *three* bones in the epipodial row, *i.e.,* in the forearm and shin, though it is now known that a fourth may be present in articulation with the distal end of the humerus or femur. Two of these represent the ulna and radius (or tibia and fibula) of land forms, the homologies of the others, which may be called "accessary epipodials", are not clear. The paddles of *Trinacromerum* are remarkably long and slender.

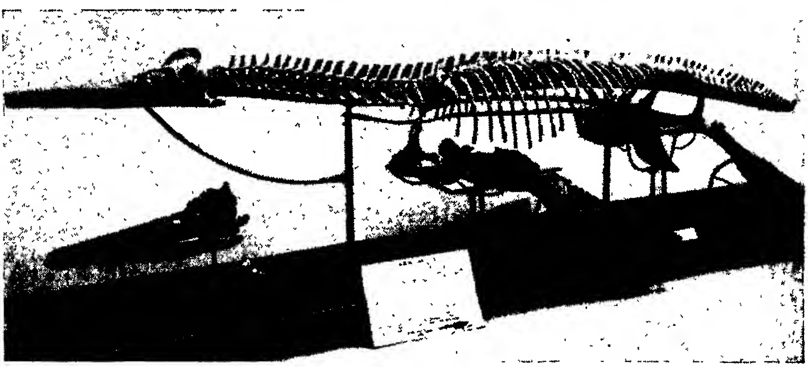


FIG. 3.—Type of Trinacromerum osborni in the K.U.M.V.P. From a photograph by D'Ambra.

Williston also described *T. anonymum,* the type of which was collected by Mudge from the upper Benton Cretaceous of Kansas, "three miles south of the Solomon". A second specimen (Yale Museum, No. 1129) was collected in 1873 by Joseph Savage from the same locality and doubtless from the same formation. One of the finest and most complete specimens of plesiosaur in the world (Fig. 3) is that now known as *Trinacromerum osborni* (type: KUMVP, No. 1300) which was collected in 1901 "in the chalk of western Kansas" by Charles H. Sternberg. The skeleton, just ten feet long, was mounted by the late H. T. Martin, and comprises 19 vertebrae in the neck, 30 in the trunk, and 25 in the tail, which however tapers very abruptly toward its tip and may have had a very few more caudal vertebrae. Williston in the original description of this specimen notes that "there are not a few new and strange characters presented by this skeleton, especially in the skull, . . . such as the presence of two separate and disconnected supraoccipital bones, peculiar frontal bones, the presence of a quadrato-jugal, and of a well-ossified sclerotic ring, etc. The pectoral girdle, which, with the pelvic girdle, is marvelously complete and undistorted, has a

large interclavicular foramen, never before observed in these animals, though present in other forms."

Williston mentions without name or description other species of plesiosaurs (probably of the genus *Elasmosaurus*) which he had seen from "Fort Benton deposits of Kansas", *e.g.,* one, "of which a considerable part of the vertebral column is preserved at the Museum of the University of Kansas, is of great size, the dorsal centra measuring five inches or more in diameter, with a very long neck and small anterior cervicals. The specimen is from near Beloit. It represents a distinct species that may provisionally be referred to *Elasmosaurus.*" (See large individual in Fig. 2).

Recently E. S. Riggs, formerly honorary curator of vertebrate paleontology, KUMVP, has described a new species of plesiosaur from the Greenhorn Limestone formation of Kansas, under the name of *Trinacromerum willistoni.* The skull, fifty vertebrae, many ribs, pectoral and pelvic girdles, but no paddle bones, are described and figured. This specimen (KUMVP, No. 5070) "was found by a road crew in December, 1936, while making a cut on U. S. highway 81 south of Concordia. . . . The horizon is ten feet below the Jetmore Chalk member in beds which, farther west of this, have been classified as Hartland Shale member, Greenhorn Limestone formation, Cretaceous series."

This species is related to *T. osborni,* but differs in having the premaxillaries extending farther back; in having a larger maxillary series of teeth (at least 34 as compared to a possible 26 in *T osborni*), interclavicle relatively much larger and lacking the foramen. The skull is long and tapering with narrow face and short cranium. The specimen is apparently fully adult and shows no such juvenile characters as are evident in *T. osborni.* The skull is nearly 27 inches long and the mandible 31. Of the 50 vertebrae, 15 are cervicals, including the atlas and axis which are coösified.

The third family of plesiosaurs with a species known from Kansas is that called the *Plesiosauridae* Seeley, 1874. Its representative from this state is *Brachauchenius lucasi* Williston, from the "Benton Cretaceous near Delphos, in Ottawa County, Kansas." It is now in the National Museum, Washington, D. C. It was named in honor of the late F. A. Lucas, at that time director of that museum. The skull is over 43 inches long, intermediate between *Trinacromerum* and *Elasmosaurus.* The parietal region lacks the thin high crest of *Trinacromerum* and *Polycotylus,* and is low and rounded on its upper surface. The teeth are fewer and smaller than in

these genera, and are coarsely striated. However, the most distinctive characters of *Brachauchenius* are the broadly united palatines, the small number of 13 cervical vertebrae, and the absence of vascular foramina on the under side of the cervical centra.

The fourth family of plesiosaurs represented in Kansas is called the *Elasmosauridae* Cope, 1870. Six genera and species are recognized by Welles, the latest student of this group. The type genus is *Elasmosaurus* Cope, of which a skeleton about 42½ feet long is in the Museum of the Philadelphia Academy of Science. The cervical vertebrae number 60 to 76, the largest number found in any vertebrate, and are longer than high, with short, single-headed ribs. This is an upper Cretaceous form found not only in North America, but also in Russia, Australia and New Zealand. The type species is *E. platyuris* Cope, and the type specimen, described by Cope in 1868, was found "in a ravine 15 miles NW of Fort Wallace, Kansas. The ravine debouched into the Smoky by the Henshaw Springs." Geologically speaking, it came from the Basal Pierre, upper Cretaceous, and is notable for being the largest known plesiosaur.

A second genus is called *Styxosaurus* by Welles and the type species is *Styxosaurus snowii* (Williston) ; this specimen (KUMVP, No. 1301) came from Hell Creek, Logan County, Kansas, in the Niobrara Cretaceous, and was described by Williston in these Transactions for 1891, under the generic name *Cimoliasaurus*. Welles recognizes a third form as *Thalassonomosaurus marshii* (Williston) from the Niobrara Cretaceous of Logan County; this was described in 1906 by Williston as *"Elasmosaurus ? marshii"*. The type is No. 1645 in the Museum of Yale University. A second species, *T. nobilis* (Williston), from the Fort Hays limestone, basal Niobrara, in Jewell County, is also in the same museum (No. 1640). Welles has called a fourth genus *Thallasiosaurus,* the genotype of which is *T. ischiadicus* (Williston), from the Niobrara Cretaceous of Logan County. In addition to the type (KUMVP, No. 1327), it is represented in the University of Kansas Museum by a number of other specimens. It was more massive than *Trinacromerum osborni.*

A fifth genus (the last so far recorded from Kansas) is *Ogmodirus,* with one species, *O. martinii* Williston and Moodie, from the Cretaceous of Cloud County (type: KUMVP, No. 441). "It is of peculiar interest", as its authors point out, "in presenting certain intermediate characters between the *Elasmosauridae* and *Plesiosauridae,* the two distinctive families of long-necked plesiosaurs. The two families differ, aside from the skull, especially in the struc-

ture of the pectoral girdle." The material upon which this genus is based "was collected in 1909 by Mr. C. Boyce in Cloud County, associated with the remains of another plesiosaur, and presented by him to the University of Kansas. Its horizon is probably the Fort Hays limestone of the basal Niobrara, though possibly, but improbably, from the uppermost horizon of the Benton." In this genus the cervical vertebrae are short, being almost as wide as long, and increase gradually in size from fore to aft.

The next order of reptiles with fossil representatives in Kansas is that termed the *Squamata,* which includes lizards, mosasaurs, snakes, and some other related forms. The snakes (*Serpentes* or *Ophidia*) may be quickly disposed of here, for no fossil serpent has actually been described from this state, although in a number of instances fragmentary remains, such as isolated vertebrae or portions of jaws have been found and recorded from late Tertiary and Quaternary deposits, but such elements have not been sufficiently diagnostic for specific or even generic identification. The same remarks apply to the lizards except for four species described by Dr. E. H. Taylor from the Rexroad formation, upper Pliocene, about sixteen miles southwest of Meade, Meade County, Kansas.

Gilmore in 1928 recorded 27 genera and 63 species of fossil lizards from North America, of which only three species were from all the Miocene, Pliocene and Pleistocene, and Olson in 1937 reported a new saurian genus, *Tetralophosaurus,* from the Miocene of Nebraska. Hence Taylor's report of four new species and one new genus from the upper Pliocene alone, in Meade County, is highly significant. Two of the three previously recorded species belong to *living* genera, *i.e.,* one, a "horned toad", *Phrynosoma,* and the other, a "collared lizard", *Crotaphytus.* Two of Taylor's new species likewise represent two living genera, while his other two are assigned to a new genus of somewhat doubtful affinities, *Eumecoides.*

The material from Meade County was collected by Dr. C. W. Hibbard and party, from the University of Kansas Museum. It is all from the Rexroad fauna, upper Pliocene. One of Taylor's new species is *Cnemidophorus bilobatus* (type: KUMVP, No. 5084), of a size somewhat larger than most living species of that genus, including *C. sexlineatus* which lives in Meade County today. A second specimen of this "whip-tail lizard" (KUMVP, No. 5081) was obtained at the same place. This genus belongs to the family *Teiidae,* established by Cope in 1871.

Taylor's second species is *Eumeces striatulatus.* The type

(KUMVP, No. 5079) indicates a form larger than most species of *Eumeces* living in southwestern Kansas, being most nearly approached by *E. obsoletus,* which, however, has decidedly smaller teeth than those of the fossil species. At least three other specimens (KUMVP, Nos. 5080, 5079A, and 5129C) are referred by Taylor to this new species.

The remaining two new species described by Taylor are assigned to a new genus, *Eumecoides.* The genotype, *E. hibbardi* (type: KUMVP, No. 5099) was collected by Hibbard in 1936. It differs from the second species of the genus, *E. mylocoelus* (type: KUMVP, No. 5115) in the number and shape of its teeth. *E. hibbardi* has only 18 mandibular teeth, which are only moderately compressed laterally, while *E. mylocoelus* has 21 to 23 mandibular teeth, which are strongly compressed. The relationship of this genus to Eumeces is indicated more by general conditions than by any series of close specific resemblances.

The totally extinct group of the *Mosasauria* presents quite a different picture. No assemblage of extinct reptiles can exhibit a larger assemblage of fossil remains in the museums of the world than can the mosasaurs, and no other region, larger or smaller, has been equal to Kansas as a collecting ground for them. "Since the first specimen was discovered by Dr. Turner, of Fort Wallace, in 1868, and taken east by Le Conte, to be shortly afterwards described by Cope, many thousands of these animals have been colected" (Williston) in this state. Yale has over a thousand specimens, largely collected by Marsh and his field parties; several hundred are in the University of Kansas Museum, collected by Williston, Martin, and others; while many more have gone from this state to other museums both in America and abroad. As a group, mosasaurs are now known from four remote regions of the world—North and South America, Europe and New Zealand.

Five genera have been recorded from Kansas: *Tylosaurus, Platecarpus, Brachysaurus, Mosasaurus,* and *Clidastes.* These are large to very large marine lizards, apparently not far removed from the living monitors (*Varanus*), but with paddle-like limbs, ending in short, webbed, clawless feet, and with only seven cervical vertebrae. The head is more or less elongated, as is the body also. The tail is long and compressed, to serve as the chief organ of locomotion in the water. The mosasaurs varied in length from six or eight to forty, or perhaps even fifty feet. The most striking structural peculiarities are: (1) the union of the anterior ends of the mandibular

rami by a ligament; and (2) a true hinge-joint just back of the mandibular tooth-row between the angular and splenial elements of the lower jaw. In common with most other aquatic reptiles there is a ring of sclerotic plates in the eyeball. There is no sacrum and the pelvis is greatly reduced.

The mosasaurs flourished during the upper Cretaceous times but were probably descended from subaquatic lizards of the late lower Cretaceous period. Though the first mosasaur was found in 1780 in Belgium, the generic name, *Mosasaurus,* was not applied to it until 1822, when Conybeare coined the word from *Mosa,* the Latin name for the river Meuse, near which it had been found, and *saurus,* the Greek for lizard.

Three types of mosasaurs are recognized, all of which are represented by specimens from Kansas. The first type includes *surface* swimmers only, with body and tail elongated. The trunk comprises as many as 35 vertebrae, while the tail has a pronounced subterminal dilation in the vertical plane. The vertebral articulations are strengthened by the development of zygosphenes; the wrist and ankle are composed of well-ossified elements, and there is little or no increase in the number of the phalanges. This type is represented by the genera *Mosasaurus* and *Clidastes* (Fig. 4). Secondly, there is the type of deep-sea-dwelling forms in which the neck and body are decidedly shorter, the latter with only 22 dorsal vertebrae; the tail is more uniformly flattened; the wrist and ankle are less well ossified, and the phalanges are present in increased numbers. This type is exemplified by the genus *Platecarpus.* The third type comprises the deep-water, diving species which have the head longer and the ear-openings protected by heavy cartilages; a relatively short neck and body, the latter with only 22 vertebrae; the tail much longer and greatly compressed; the wrist and ankle elements almost entirely cartilaginous; and the phalanges much greater in number. In general they are of large size, in the case of *Tylosaurus* sometimes over forty feet in length. All the mosasaurs were doubtless covered with small imbricating keeled scales very similar to those on the living monitor lizards, as shown by distinct impressions of the scale-covered skin of *Tylosaurus proriger* in the University of Kansas Museum, (KUMVP, No. 1075).

The genus *Tylosaurus* includes moderately large to very large species with not to exceed a total of 120 vertebrae. In the paddles, the ankle and wrist are mostly not ossified; the phalanges are very numerous and the fifth finger is not reduced. The hind paddles are

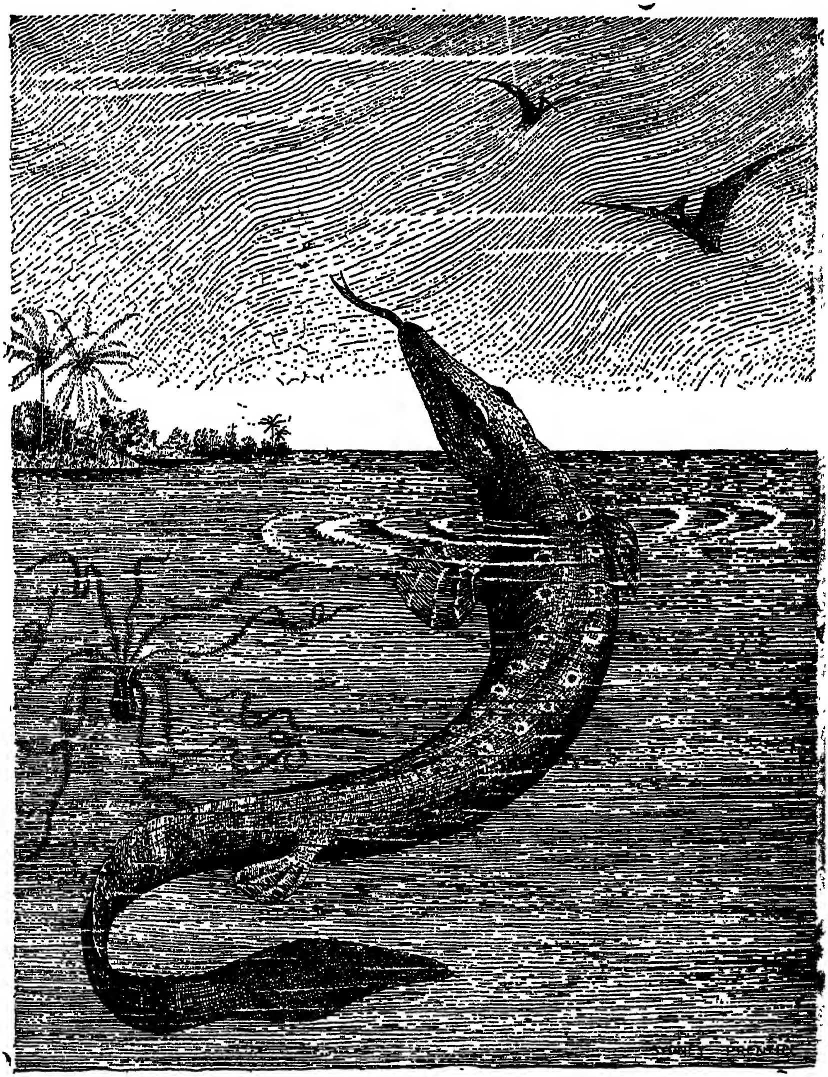


FIG. 4.—Clidastes, from the original drawing by Sidney Prentice. First published by Williston, Univ. Geol. Survey of Kansas, Vol. 4, Part 5, Plate 71, 1898.

as large as the front ones. The snout is much extended anterior to the teeth, while the nares are situated well back, half-way, at least, toward the eyes.

The first mosasaur ever described from Kansas was *Tylosaurus proriger* Leidy. The type, now in the Museum of Comparative Zoology, Harvard University, was found in the vicinity of Monument

Rocks, a Cretaceous formation in Gove County. This is the most common mosasaur in this state and occurs at nearly all horizons in the Niobrara beds. It is represented by several specimens in the University of Kansas Museum, among which may be mentioned a skull (KUMVP, No. 1033); and No. 1029 which came from the mouth of Twelve Mile Creek, a tributary of the Smoky Hill River in Logan County.

Tylosaurus dyspelor Leidy, with a length of 35 feet and a head 4 feet long, is larger than most other species of Kansas tylosaurs. The type specimen, in the Yale University Museum, came from the Niobrara chalk near Fort McRae, New Mexico, but there are specimens from Kansas, such as KUMVP, No. 1032, from the mouth of Twelve Mile Creek, Logan County. The most reliable specific distinction in this species is its very much larger size and not any unique structural differences. Its skull is 40 inches or more from the tip of the snout to the occipital condyle, while the mandible is 48 or more inches long. The quadrate is seven inches or more in length, but resembles in shape the same element in other tylosaurian species (Fig. 5).

Tylosaurus micromus, originally described by Marsh, cannot be identified by the characters given by that author. However, Merriam and later students state that it may be distinguished from the two preceding species "by its smaller size, by the more lightly formed bones of the skeleton, and by the shape of the quadrate." Nevertheless its distinctness is truly problematical and it may eventually prove to be only a young individual of either *T. proriger* or *T. dyspelor.* The same remark may be made concerning *Tylosaurus nepaeolicus* Cope.

Platecarpus Cope, 1869, has the trunk short and the tail long; the hind limbs functionally pentadactyl; the ankle and wrist not completely ossified. The species belonging to this genus are medium-sized mosasaurs with a very obtuse snout which does not project beyond the teeth. The teeth are slender and recurved. The nares are situated well forward. The total number of vertebrae is 116, of which 86 or more are caudal.

A mosasaur described by Cope as *Platecarpus crassartus,* from the Fort Pierre of extreme western Kansas, may not have been correctly assigned to this genus, but may belong to Williston's genus *Brachysaurus,* otherwise not recorded from Kansas, but originally described from the upper Cretaceous of South Dakota. In the shape and relative size of its limb bones and vertebrae it differs from typical

FIG. 5.—Right quadrate bone of Tylosaurus proriger. Nat. size. Drawn by Miss Ann Murray, artist on the staff of Dyche Museum.

Platecarpus, the limbs being much smaller, and Cope himself noted that in this species the vertebrae are as much distinguished for their shortness as those of *P. latipinnis* are for their elongation. The articular faces are but little broader than deep, and their planes are slightly oblique. The inferior face is somewhat concave in the long dimension. The zygapophyses are stout and there are no distinct rudiments of zygosphenes.

Platecarpus ictericus Cope, 1870, was the first species of this genus described from Kansas. However, except for size, specific characters are difficult to note. It is the largest of all known species of *Platecarpus.* One specimen in the Yale University Museum (No. 68) was "found by Mudge on the South Fork of the Solomon river, in Graham County," in 1875, and "is especially valuable in showing the natural position of the digits and their relations to each other. . . . There were at least four phalanges in the first finger, six in the

second and third, five in fourth, and four in the fifth" (Williston). The paddle as preserved is 29 inches long and must have been at least two inches longer when complete. The head is 23 inches from the tip of the snout to the occipital condyle, and is thus very small in comparison with the size of the paddle.

Platecarpus coryphaeus Cope, 1871, is the best known and most common species of all the Kansas mosasaurs. The type and accompanying specimens were found by Mudge "on the north bank of the Smoky Hill river, 30 miles east of Fort Wallace, Kansas" (Cope). In this species the premaxillaries are short and obtuse; the maxillae are relatively short and stout; the broad frontal is deeply emarginated posteriorly for the reception of the parietal and bears a thin, sharp median carina along its posterior half; the postfrontal usually touches the frontal, but does not articulate at all with the squamosal; the jugal is stout and somewhat L-shaped; the pterygoid has 10 teeth arranged in a reverse curve; the moderately large parietal foramen is usually wholly within the parietal at its posterior end; the quadrate (Fig. 6) has a greatly elongated suprastapedial process,

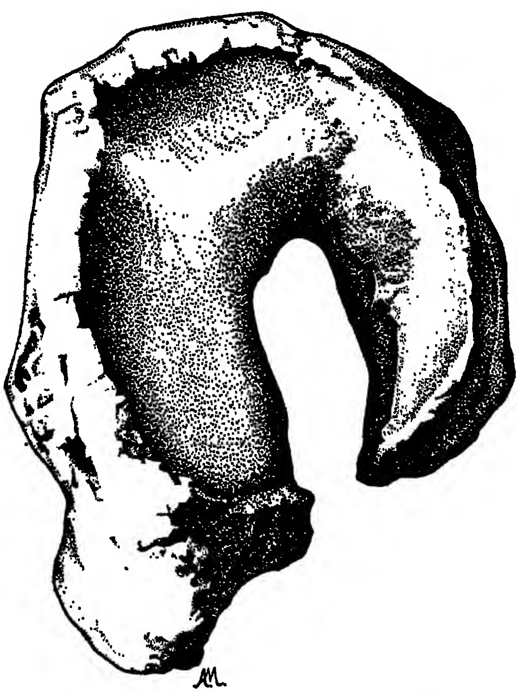


FIG. 6.—Left quadrate bone of Platecarpus coryphaeus. Nat. size. Drawn by Miss Ann Murray.

but the alar process of the upper articular surface is short and stout; there is a large oval stapedial pit rather high on the inner surface. The dentary comprises more than half the entire length of the mandible, and bears 11 teeth, with 8 or 10 foramina in a row below them exteriorly. Back of the middle of the mandible there is an imperfect joint between the angular and splenial bones, which admitted motion in both lateral and vertical directions, but chiefly the former.

Williston lists three other species of *Platecarpus*, namely, *P. mudgei* Cope, 1870; *P. gracilis* Marsh, 1872; and *P. simus* Marsh, 1872, but inclines to the opinion that they are really all synonyms of *P. coryphaeus* Cope, 1871, though he acknowledges that his conclusion may be erroneous, since these species were inadequately described by the original authors. If his opinion be correct, *P. mudgei* would replace the name *P. coryphaeus* on the ground of priority.

The type of *Platecarpus mudgei* consists of a series of vertebrae and portions of the skull and scapula, collected at a point six miles south of Sheridan, Wallace County, Kansas. Cope based his distinction of this species on the rudimentary zygosphenes in the vertebrae, the plane proximal articular surface of the quadrate, and the opening of the auditory meatus on an obtusely angled ridge, ***not sunk in a depression*** as in other species.

Platecarpus planifrons (Cope), 1874, is a doubtfully valid species based on "a large part of the cranium, including the quadrate bone, cervical and dorsal vertebrae and fragments of other elements." Cope himself assigned the species to *Clidastes* where it certainly does not belong. While Williston assigns it to *Platecarpus*, he acknowledges that the functional zygosphenes indicate rather the genus and species *Sironectes anguliferus* Cope, where it probably should be placed.

Platecarpus clidastoides Merriam was based on fragments of a skull and some vertebrae. A translation of Merriam's account indicates that this species "is characterized by the peculiar parietal that shows anteriorly a low, three-cornered field in the middle of which is the comparatively small, round parietal foramen". It was originally collected by Charles H. Sternberg "on the Smoky Hill river", but without indication whether it came from the Niobrara or the Fort Pierre.

Merriam described another species of this genus under the name *Platecarpus oxyrhinus*, distinguished from all other species by

the elongation of the rostrum, as in *Clidastes* except the elongation is not so great (translated from Merriam). The collector and locality are the same as in the last preceding species.

MOSASAURINAE

This subfamily was established by Williston to contain the genera *Mosasaurus* and *Clidastes,* and is characterized by the tetradactylate hind feet; the fully ossified wrist and ankle bones; the tail much compressed distally; chevrons coössified with the centra; rostrum short, obtusely conical; and the quadrate small, with a suprastapedial process of only moderate length.

MOSASAURUS Conybeare, 1822

In this genus the zygosphenes are vestigial or wanting, and this very slight character seems to be the only one, aside from size, that separates *Mosasaurus* from *Clidastes.* The various species of *Mosasaurus* are very large, some of them among the largest of the family, while those of *Clidastes* are either very small or at most of only moderate size. There is no known species of the genus *Mosasaurus* from Kansas.

CLIDASTES Cope, 1868

This genus comprises small to moderately large species, all of which are slender. The obtusely conical rostrum is formed by the short premaxillaries, which project but little in front of the teeth. The moderately dilated external nares lie anteriorly on the rostrum. The quadrate is relatively small, the suprastapedial process reaching to about the midle of its length (Fig. 7). The vertebrae have functional zygosphenes. The chevrons are long and coössified with

FIG. 7.—Right quadrate bone of Clidastes velox. Nat. size. Drawn by Miss Ann Murray.

the caudal centra. The tail is much compressed and the posterior spines are much elongated, making the tail a very efficient organ of locomotion. The limbs are small, the hinder less than the front ones in size. In the hind foot the hallux ("big toe") is vestigial or absent.

At least eight species of Clidastes have been described from Kansas by Cope, Marsh, Merriam, Williston and Case, of which no less than five are indeterminable or synonyms of previously named species.

Clidastes stenops Cope was described in 1871 from "Kansas". It is distinguished by the absence of the usual anterior expansion of the prefrontal bone over the orbit, in which respect this species more nearly resembles *Platecarpus;* yet in every other respect it is a true *Clidastes.*

Clidastes tortor was described by Cope in 1871. The material in the Museum of the University of Kansas consists of one nearly complete skeleton (KUMVP, No. 1000) and the incomplete remains of five others. The first was collected by West in "the Kansas chalk", probably Niobrara. This is certainly the most common species of Clidastes found in this state. This species had been previously described by Marsh as *Edestosaurus dispar;* other synonyms are *E. rex* Marsh and *Clidastes medius* Merriam. Among its distinctive characters are: "The articular facets in the cervicals are a broad, transverse oval, faintly emarginate above for the neural canal. The quadrate has the same general form as in [other species of *Clidastes*], but the external angle is situated farther back, and has a notch in its posterior margin directly above the meatal pit. The posterior superior process is shorter, with a compressed free end. The teeth are curved and somewhat compressed. The enamel is smooth and shows faint indications of broad facets on the basal half. There were at least 15 pterygoidal teeth. The coracoid is not emarginate." (Marsh).

Clidastes velox is represented in the University of Kansas Museum by a practically complete skeleton and skull (KUMVP, No. 1022).

Clidastes westii Williston and Case, 1892, was based upon a complete lower jaw, quadrate, fragments of the skull, the larger part of the vertebral column, and the incomplete fore and hind paddles. The estimated length of the entire vertebral volumn, as given by Williston, is 15 feet 4 inches. The skull was nearly two feet long, so that the total length when alive may have been slightly over 17 feet, making this one of the largest species of the genus. It was very much stouter

than either *C. velox* or *C. tortor,* which about equalled it in length. "It is upon these remarkably stout proportions, and the shape of the articular faces . . . that the species is chiefly disitnguished from those previously known. The articular surfaces of the basal caudal vertebrae are remarkably triangular in shape, with the angles rounded and the sides of nearly equal length. . . . The paddles . . . show much stouter proportions than in any other known species" (Williston). The type (KUMVP, No. 1026) was collected by Charles H. Sternberg, from near McAllaster, in the Fort Pierre.

Ancylocentrum overtoni (Williston), (type KUMVP, No. 950), from the Fort Pierre Cretaceous, Cheyenne River, Custer County, South Dakota, collected by T. R. Overton in 1894, has been *erroneously* credited to Kansas by O. P. Hay.

For an interesting and valuable comparison of the three genera of mosasaurs most common in the Kansas chalk, the reader is referred to Williston's paper, *"Restoration of the Kansas Mosasaurs"*, in the report of the University Geological Survey of Kansas, Vol. IV, pp. 209-216, 1898.

Archosauria

Crocodiles, dinosaurs, pterosaurs, and related reptiles constitute the *Subclass Archosauria,* or "ruling reptiles". All are characterized by the presence of *two* temporal fossae; no teeth on the palate; no parietal foramen; no supratemporal, interparietal nor tabular bones in the skull. The vertebrae are variable. Characteristically bipedal, though some are secondarily quadrupedal, such as the crocodiles and ceratopsian dinosaurs.

Of the archosaurs, the *Order Crocodilia* stands at the top of the living reptiles, and they occur in Asia, Africa, Australia, North and South America, and the West Indies. This order includes three distinct types: (1) the *crocodiles* in the stricter sense, with a *triangular* head, the jaws rounded in front and the powerful teeth irregular in size; (2) the *alligators* and *caimans,* with broad and flat head, the sides of which are almost parallel; a pair of large teeth on the lower jaw fits into pits or sockets *in* the upper jaw when the mouth is closed. In the crocodiles such a tooth is received into a groove on the *outside* of the upper jaw, and is exposed when the mouth is closed. (3) The *gavials,* now confined exclusively to rivers of interior India, in the torrid zone, are distinctly more aquatic than the crocodiles and alligators, and resemble the more ancient crocodiles in having the snout greatly elongated and very slender.

The earliest known crocodilian is a little fellow about a foot or

so in length from the Triassic of Arizona, known as *Protosuchus,* of which a practically complete skeleton with much of its dermal armor is known. It is notably similar to the thecodont reptiles which were ancestral to the dinosaurs and birds as well as the crocodilians. Yet, despite its thecodont resemblances, *Protosuchus* is unmistakably a crocodile with a rather short but pointed head. Its hind limbs are much larger than the fore legs, and its body and tail were protected by large rectangular plates or scutes strongly suggestive of those in *Dakotasuchus* described below.

The only fossil crocodilians known from Kansas, occur in the Cretaceous. With one exception they are represented by such fragmentary remains that little can be said about them. One such specimen was described—*but not named*—by Williston from the lower Cretaceous of Clark County. From the Benton, upper Cretaceous, of Kansas Cope described another crocodile, *Hyposaurus vebbii,* on the basis of a single anterior cervical vertebra, which is 37 mm. long; diameter anteriorly, 32 mm. vertically and 31 mm. horizontally. It is shorter and stouter than the corresponding vertebra of *Hyposaurus rogersii* from the New Jersey Cretaceous. Cope's specimen was obtained in a bluish stratum encountered in digging a well in Brookville, Saline County, Kansas.

By all odds the most complete specimen of a crocodile ever found in Kansas is one found sometime before 1910 by a geologist, Mr. A. Wheeler Jones, who presented it to Kansas Wesleyan University. It was enclosed in a concretion of Dakota sandstone such as occurs in large numbers a few miles west of Salina, Saline County, where the specimen was undoubtedly collected, though the exact location is not now known. This is apparently a mesosuchian crocodile and was described in 1941 by Professor M. G. Mehl of the University of Missouri, under the name of *Dakotasuchus kingi.* The present writer is indebted to Dr. Mehl for all the information he has in regard to this crocodile. Apparently the animal when first enclosed in the concretion may have been complete, but through weathering parts are now missing. As Dr. Mehl points out, one of its most striking features is the presence of a semi-rigid dorsal shield, comprising twenty pairs of rectangular plates covering completely the top and sides of the animal from the mid-length of the neck to the base of the tail. Perhaps the missing part of the tail was also covered with such plates, completing a striking resemblance to *Protosuchus,* noted above. Measured along the convex surface, this shield, as preserved, is about 50 inches long and over 17 inches wide. While

the number of pairs of these plates corresponds to the number of vertebrae overlain by them, the vertebral spines and the plates were apparently not fused together. All the plates are more or less rectangular in shape with their lengths two or three times their widths, and the posterior margin of each overlaps slightly the anterior margin of the next succeeding plate. A more or less rigid armor of four or five rows of heavy, closely fitting polygonal plates, mostly hexagonal, almost completely covered the ventral surface of the body. Many of these plates are 1 cm. or more in thickness. There are preserved 21 consecutive vertebrae extending from near the middle of the neck to and including the base of the tail. The two sacral vertebrae, as well as a modified lumbar, articulate with the pelvis through sacral ribs. A typical crocodilian character is the presence of a system of *ventral* ribs in the abdominal portion of the trunk. The shoulder girdle is represented only by natural *molds* from which Dr. Mehl secured nearly perfect plaster casts of the scapula ("shoulder-blade") and coracoid. The scapula is somewhat over 6 inches long parallel to its posterior margin, while the coracoid is 8 inches, or slightly more, along its greatest diagonal. An interclavicle is present in the form of a long, slender, spatulate element that is comparatively thin. All parts of the pelvis are represented, with a very large acetabulum to receive the head of the femur, and the whole is typically crocodilian. Assuming the usual crocodilian proportions of the missing skull and tail parts, the specimen indicates a total length in life of between ten and twelve feet. It was a mature individual. The limbs are missing, but, "if as Williston suggested, the broad short scapula is indicative of stout, powerful legs, *Dakotasuchus* was probably more at home on the land than in the water. This is in keeping with the comparatively heavy flexo-rigid armor and may well account for the scarcity of remains of this type of crocodilian" (Mehl).

The type material is preserved in the museum of Kansas Wesleyan University at Salina, and was specifically named *"kingi"* in honor of Professor King, former dean of the college, through whose kindness Dr. Mehl was permitted to study the specimen.

There is in the University of Kansas Museum of Vertebrate Paleontology at Lawrence a series of over 50 tracks of a large Cretaceous crocodilian, discovered by Mr. C. T. Brandhorst of Sylvan Grove, Lincoln County, Kansas, at a site a few miles southwest of that town. Dr. C. W. Hibbard and the late W. S. Long collected over fifty of these tracks from an area about 7x10 feet in extent.

They are large sized impressions and may well have been made by an individual of *Dakotasuchus kingi.* No actual remains of the animal that made these tracks have been recovered.

In the Jurassic the crocodilian line diverged into two, one of which is that of the mesosuchians which persisted from the Jurassic into the Cretaceous, producing along the way a great variety of forms adapted to varied environments. This is the line to which *Dakotasuchus* most likely belongs, though definite familial assignment must await the recovery of its skull since much of crocodillian classification is based on skull characters. The second line led into the living crocodilians.

Dinosaurs

Dinosaur remains are exceedingly rare in Kansas, largely, no doubt, because deposits of Mesozoic age in this state are wholly marine in origin. Only five such finds are known to the present writer, all but one consisting of very fragmentary material. In 1872 Marsh described the type of one from the Niobrara Cretaceous of the Smoky Hill River valley "in western Kansas" under the name of *Hadrosaurus agilis,* but which is now known as *Claosaurus agilis.* In 1902 Williston recorded a specimen from the Comanchean (lower) Cretaceous of Clark County, collected several years previously by Dr. C. N. Gould, allied to *Creosaurus* or *Allosaurus,* but while doubtless a new species, "the material preserved is too incomplete to furnish even generic characters", hence he did not name it. Another dinosaur is represented by a single vertebra of a small aquatic type (KUMVP, No. 1398) from the Fort Pierre Cretaceous, near McAllaster, Logan County, collected many years ago by a University of Kansas Museum party and described but, again, not named by Williston. A fourth find consisting of six dermal plates and part of the skeleton, collected by the late Charles H. Sternberg, was described and figured by Dr. G. R. Wieland, under the name of *Hadrosaurus sternbergii.* The fifth and last find known to the present writer includes parts of the skull, vertebrae, ribs, chevrons, part of a scapula, much of the pelvis, an almost complete right hind leg and foot, and parts of the left hind leg, the humerus, ulna and radius of the right front leg, the distal ends of the left radius and ulna, two anterior metapodials, and about one hundred nearly complete dermal scutes, with fragments more or less complete of nearly two hundred other scutes.

This specimen was collected by Mr. Virgil B. Cole from the Niobrara Cretaceous of Gove County, Kansas, about 11 miles south

and a little east of the town of Hackberry in the eastern part of that county. It was sent in 1930 to the University of Missouri, where the remains were studied and described in 1936 by Dr. M. G. Mehl. The specimen is of particular interest not only because it is far more complete than any previously known dinosaur in this state, but it belongs to a little known group of specialized ankylosaurids and affords evidence of a marine adaptation in this form that is of more than ordinary interest. Dr. Mehl, to whom the present writer is indebted for all his information on this specimen, described it as a new species under the name of *Hierosaurus coleii.* The type is listed as No. 650 V. P., University of Missouri, and represents a flat bodied ornithischian dinosaur with a total length, including a moderately long, slender tail, of about 15 feet. Though only a part of the skull was recovered, the indications are that it was highly arched both transversely and antero-posteriorly. Only one tooth, probably mandibular, is complete enough to show details of the crown pattern. This is a spatulate element, nearly flat on the inner, and convex on the outer face of the crown, the cutting edge of which has a large median apical denticle and four slightly smaller accessory denticles on both its anterior and posterior edges. This tooth is very similar to one of *Stegosaurus* and had it been found disassociated from the skeleton it would probably have been ascribed to that genus.

"That *Hierosaurus coleii* was strictly aquatic seems fairly certain. The limb bones are hollow and of comparatively delicate structure. The armor, too, shows no tendency to fuse into a more or less solid carapace such as was useful to the smaller of its land dwelling relatives. The attitude of the limbs was not such as to permit efficient progress on the land. The hind foot at least was distinctly paddle-like with movement between the lower leg and the metatarsals limited, but the toes were capable of remarkable backward flexing.

"*Hierosaurus coleii* presents a peculiar combination of characters that confuse relationships. . . . It seems likely that it turned to an aquatic adaptation not long after the start toward diversity among the stegosaurid group. One culmination of this diversity was *Stegosaurus* and another a distinct trend toward the more or less perfectly armored Nodosauridae with such startling products as *Palaeoscincus. Hierosaurus* seems to have traveled a short distance along the normal nodosaurid line of development and then turned toward aquatic adaptation. It combines in this way a more ancient foot structure, in some respects, and a more primitive den-

tition than most of the Nodosauridae. To the writer (Mehl) it seems most logical to place *Hierosaurus* in the family Nodosauridae and, regardless of its many differences, with the panoplosaurid group." (Mehl).

Pterosauria

The most highly specialized of all the ruling reptiles were those that acquired wings and the power of flight. This occurred twice, in one case producing those reptiles commonly called "birds", and in the second instance resulting in the order of the *Pterosauria.* While not directly ancestral to the birds, these flying reptiles were derived from the same stem-stock, known as the *Thecodontia,* a Triassic group that also gave rise to the crocodiles and dinosaurs. The pterosaurs were already well developed in the Jurassic where the earliest yet known occur and during this period attained their maximum in numbers and variety. Only a few persisted into the Cretaceous, when they were represented in Kansas by the largest species that ever arose in this order. The Jurassic pterosaurs were small—some no larger than the common house sparrow—well provided with teeth and in a few with a tail that was very long and carried a terminal expansion which served as a rudder in directing the course of flight. In all pterosaurs, the wing consists of a membrane (*patagium*) supported mostly by the forearm and the greatly elongated *fourth* finger. The hind limbs in all are relatively so weak and frail, and so inserted into the pelvis, as to suggest that walking on them must have been very difficult, if not absolutely impossible.

Two general tendencies are manifest in the history of the pterosaurs: (1) a gradual reduction or loss of the teeth from in front backwards and their replacement by a horny beak like that in birds: and (2) an increase in size from the little *Pterodactylus* of the Jurassic to the gigantic *Pteranodon* (*Ornithostoma*) of the upper Cretaceous of Kansas, which reached an extreme of 28 feet from tip to tip of its outspread wings. The latter had also a long toothless beak, while the back of the head was prolonged into a flat plate, nearly as long as the beak. This seemingly served as a rudder to guide its flight. Several specimens of *Pteranodon* are in the museum of the University of Kansas. The more notable of which (KUMVP, No. 976 and 986) includes the skull as well as the wing bones. An even better skull is No. 2212.

With the extinction of the pterosaurs in Kansas before the close of the upper Cretaceous, they disappeared completely from the earth, leaving dominance of the air to their distant cousins, the birds,

which were far better adapted to succeed in the struggle for existence. Probably, like the dinosaurs that passed away at the same time, the pterosaurs had become too large for their bodily machinery to function properly.

Glossary

adaptation: fitness in structure or function for a particular kind of environment; the process of becoming so adjusted.
alar process: a wing-like projection, or process.
allantois: an embryonic sac growing out from the hind-gut of an embryo reptile, bird, or mammal, serving for respiration and storage of excretions.
amnion (amniotic sac): a thin membraneous sac filled with watery fluid, that encloses the developing embryo in reptiles, birds, and mammals.
angular: a bone forming the angle at the rear end of the lower jaw.
aortic arch: a large artery arising from the ventral aorta and leading into the dorsal (or systemic) aorta.
arboreal: living in trees.
atlas: the first vertebra of the neck, which connects directly with the skull (from Greek mythology, where the giant Atlas supports the world on his shoulders).
auricle: the receiving chamber, or chambers, of the heart, into which the large veins open to return the blood to that organ.
auditory meatus: the external channel or canal leading to the middle ear, from which it is separated by the ear-drum.
axis: the second neck vertebra, about which the atlas rotates to turn the skull.
bipedal: two-footed; walking on the hind feet only.
carapace: the hard armor covering the back of a turtle.
carina: a keel or ridge for the attachment of muscles.
carnivorous: feeding on the flesh of animals.
caudal: pertaining to the tail, or posterior part of the body.
centrum (pleural, *centra*): the body of a vertebra, which bears various processes.
ceratopsian: a horned dinosaur.
cervical: pertaining to the neck.
chelonian: a turtle or tortoise.
chevron: a V- or Y-shaped bone attached to the ventral side of caudal vertebrae.
clavicle: a bone in the shoulder girdle; the "collar bone".
condyle: an articular process on a bone taking part in a movable joint.
coössified: joined together by the growth of bone tissue.
coracoid: a prominent bone in the shoulder girdle of reptiles and many other vertebrates.
cormorant: a swimming, diving fish-eating bird.
cranium: the skull, especially that part enclosing the brain.
crossopterygian: a primitive fish with lungs and lobed fins.
crural: pertaining to the lower leg region, or shin.
cryptodiran: a common type of turtle which can withdraw its head into its shell by means of a vertical S-shaped bend of the neck.
cynodont: one of a primitive group of early reptiles that had its teeth differentiated into incisors, canines and cheek-teeth; "dog-toothed".
dentary: the chief bone in the lower jaw, which bears teeth.
dermal: in, of, or derived from the skin.
dermsupraoccipital: in reptiles, a dermal plate of bone forming the expanded upper part of the occipital complex of bones, at the back of the skull.
desiccation: the act or condition of drying out.
diapophysis: a lateral process on a vertebra.
emarginate: notched in the margin.
embolomerous: having the vertebral centra divided into two cylindrical parts (intercentrum and pleurocentrum), one lying behind the other.

epicondylar foramen: an opening near the distal end of the upper-arm bone (*humerus*).
epidermal: of or derived from the outer layer of skin (*epidermis*).
epipodial: pertaining to the lower arm or lower leg (shin); said of bones such as the ulna and radius, or tibia and fibula.
facet (*articular*)*:* a smooth area to facilitate the movement of a bone at a joint.
femoral: pertaining to, or located in the region of the thigh (see *femur*).
femur: the long bone in the upper leg extending from the hip to the knee.
fibula: the smaller of the two bones of the lower leg or shin.
foramen: an opening in or through a bone.
fossa: a groove, or depression.
genotype: the typical species of a genus.
habitat: the natural or usual dwelling place of an individual or group of animals.
hallux: the first, or big toe on the hind foot.
humeral: pertaining to the humerus: located in the upper arm.
humerus: the long bone in the upper arm extending from the shoulder joint to the elbow.
insectivorous: feeding upon insects and related small animals.
intercentrum: one of the separate elements in a reptilian vertebra (see *embolomerous,* above).
interclavicle: a bone in the anterior median part of the chest region (*thorax*) between the proximal ends of the two clavicles ("collar bones").
interclavicular: lying between the proximal ends of the clavicles.
interpterygoidal vacuity: a vacuity between a pair of pterygoid bones (see *pterygoid*).
invertebrate: an animal without a backbone; backboneless.
jugal: a bone occupying the central part of the arch of "cheek bones".
lecithin: a rich compound constituting the chief part of egg yolk.
malacophagous: feeding upon hard-shelled animals, such as clams or crabs.
mandible: the lower jaw.
mandibular ramus: one of the two bones constituting the lower jaw; generally distinct except in the higher mammals where the two are fused at the front of the jaw.
maxilla: the bone in the upper jaw bearing the canine and cheek teeth.
meatal pit: a pit in the quadrate bone of certain reptiles, leading to the middle ear.
meatus: the external canal or channel leading in to the middle ear; closed internally by the ear-drum.
metamorphosis: extreme change of form; applied to the transformation of a tadpole into a frog, or caterpillar into a butterfly.
mosasaur: one of the extinct marine lizards of the Mesozoic Era.
nares: nostrils; internal or external openings of the air passages in the head of a vertebrate.
neural canal: a passage-way through the vertebral column to enclose the spinal cord of the central nervous system.
notochord: the elastic cellular axial rod in early embryos of all vertebrates; it is either surrounded or replaced by the vertebrae in the higher forms.
occipital: a bone constituting a part of or the whole of the posterior part of the skull; a multiple element in reptiles.
ossified: composed of bone.
palatal: pertaining to or occupying the palate, or roof of the mouth.
palatine: a bone forming a part of the palatal region of the skull.
parasphenoid: a long, often dagger-shaped bone, lying in the median ventral axis of the skull of most amphibians and some reptiles.
parasternal (ribs)*:* situated near the sternum or breast-bone; said of ribs that join the sternum.
parietal: a bone (or pair of bones) forming the roof of the cranium, between the frontal and the occipital.
parietal foramen: an opening in or between the parietal bones for the accommodation of the third eye in many amphibians and reptiles.

patagium: the extensive membrane stretching between the fingers and the body to form the wing surface in pterodactyls and bats.
pectoral: pertaining to the shoulder.
pedal: pertaining to the foot.
pelvis: the hip bones collectively.
penguin: a flightless, fish-eating bird of the southern hemisphere.
pentadactyle: five-fingered or five-toed.
phalangeal: pertaining to the phalanges.
phalanges: the series of small bones in the fingers and toes of vertebrates.
plastron: the "breast-plate", or hard bony protective plate on the ventral side of the body of a turtle.
pleurodiran: one of a group of turtles which cannot draw its head straight back, but lays its head and neck to one side between the margins of its shell for protection.
pollex: the first finger, or thumb, of the hand or fore foot.
postorbital: a bone in the skull lying just back of the orbit of the eye.
precoracoid: a bone of the shoulder girdle of reptiles lying in front of the coracoid, on the ventral side of the pectoral region.
premaxilla: the front bone of the upper jaw, which bears the incisor teeth.
prevomer: one of a pair of bones (often bearing teeth) in the front part of the palatal region of the skull in reptiles.
pterygoid: one of a pair of bones on the base of the skull just posterior to the palatines.
quadrate: that bone in the skull of amphibians, reptiles and birds, with which the posterior end of the mandible articulates.
quadrato-jugal: in many reptiles, a bone just back of and in series with the jugal, forming a part of the arch of "cheek-bones".
radiation: branching out from a common center; diversification along various lines from a common ancestral stem.
radius: one of the two bones in the fore-arm; sometimes, as in man, capable of rotation so as to turn the hand over.
ramus (pleural, *rami*): a branch; one of the two halves of the lower jaw, which may or may not unite by coössification in front to form the mandible.
rostrum: the anterior part of the snout region; in some reptiles, a bone anterior to or over the premaxillae in this region.
sacral: pertaining to the sacrum.
sacrum: one to several vertebrae (in the latter case, often fused together), which articulates with the pelvis or hip-bones.
saurian: a reptile (from the Greek, meaning "lizard").
sclerotic plates: a ring of flat bones lying in the eye-ball which gives additional strength.
scute: a plate of dermal or epidermal origin on the body surface of a reptile.
Sphenodon: a small, very peculiar, lizard-like reptile confined to New Zealand; noted for the possession of a third eye.
spinous process: the dorsal median process of a vertebra.
splenial: one of the bones in the lower jaw of reptiles.
squamosal: a plate-like bone on the side of the skull; it forms a part of the "temporal" bone in man.
squid: a mollusc related to the octopus.
stapedial pit: a pit which accommodates one end of the stapes, or stirrup bone, of the middle ear.
stegocephalian: an extinct type of amphibian the head of which was roofed over solidly with bone ("roof-headed").
subaquatic: partly living in the water.
supraoccipital: the upper bony element at the back of the skull in many reptiles.
suprastapedial process: a process of the quadrate bone in the mosasaurs lying over the stapes (or, "columella").
supratemporal: a bone of the skull in reptiles lying above the squamosal.
tabular: a bone occupying the postero-lateral corners of the skull in many reptiles.

tarsal: pertaining to the ankle (*tarsus*).
temporal (region): a bone, or region in the skull occupied by the squamosal in reptiles; by the temporal in man.
terrestrial: living habitually on the ground, as a horse or man.
tetradactyle: four-fingered, or four-toed.
tetrapods: animals with four legs.
tibia: one of the two bones in the lower leg or shin; generally the larger of the two, the other being the *fibula.*
ulna: one of the two bones in the fore-arm or front leg of a tetrapod; generally the larger of the two, but may be reduced, especially in mammals.
vascular foramen: an opening through a bone for the passage of a blood-vessel.
vascularized: provided with blood-vessels.
ventral rib: a rib lying in the ventral wall of the body and articulating above with a "true", or parasternal, rib.
ventricle: the lower chamber (or two such) in a vertebrate heart.
vomer: a median bone in the anterior part of the facial region of the skull.
zygapophyses: processes on the anterior and posterior faces of vertebrae which add strength to the intervertebral articulations.
zygosphene: a peculiar type of articulating process, in addition to the zygapophyses, on the vertebrae of certain reptiles. It is often a triangular projection fitting into a corresponding depression in the next adjacent vertebra.

Bibliography

Brown, Barnum, 1908: The Ankylosauridae, a new family of armored dinosaurs from the Upper Cretaceous: Bull. Am. Mus. Nat. Hist., 24, 187-201.

——— 1914: Stomach Stones and Food of Plesiosaurs: Science (n. s.), Vol. XX, pp. 184-185.

Camp, Charles L., 1923: Classification of Lizards: Bull. Amer. Mus. Nat. Hist., Vol. 58, Art. 11, pp. 289-481.

Case, E. C., 1903: The Structure and Relationship of the American Pelycosauria: Amer. Naturalist, Vol. 37, pp. 85-102, 10 figs.

——— 1911: A Revision of the Cotylosauria of North America: Publ. Carnegie Instn. Washington, No. 145, pp. 1-122, plates I-XIV, with 52 text figures.

Cope, E. D., 1868: Note on the Fossil Reptiles near Fort Wallace. Page 68 of John L. LeConte's "Notes on the Geology of the Survey for the Extension of the Union Pacific Railway, E. D., from the Smoky Hill River, Kansas, to the Rio Grande", Philadelphia, Feb., 1868.

——— 1868: On Some Cretaceous Reptiles: Proc. Acad. Nat. Sci. Phila., 1868, pp. 233-242.

——— 1869: On the Reptilian Orders *Pythonomorpha* and *Streptosauria*: Proc. Boston Soc. Nat. Hist., Vol. 12, pp. 250-266.

——— 1870: On *Elasmosaurus platyurus*: Amer. Journ. Sci. (2), Vol. 1, pp. 140-141.

——— 1870: Additional Note on *Elasmosaurus*: Amer. Journ. Sci. (2), Vol. 1, pp. 268-269.

——— 1870: On Some Species of *Pythonomorpha* from the Cretaceous Beds of Kansas and New Mexico: Proc. Amer. Philos. Soc., Vol. 11, pp. 574-584.

——— 1870: [Observations on Fossil Reptiles from Kansas]: Proc. Acad. Nat. Sci. Phila., p. 132.

——— 1871: Remarks on New Fossil Reptiles from Western Kansas: Proc. Acad. Nat. Sci. Phila., pp. 297-298.

——— 1871: On the Fossil Reptiles and Fishes of the Cretaceous Rocks of Kansas: U. S. Geol. Surv. of Wyoming and Portions of Contiguous Territories: 2nd. (4th.) Ann. Rep., F. V. Hayden, U. S. Geologist, Washington, pp. 385-424.

——— 1871: Note on Some Cretaceous *Vertebrata* in the State Agricultural College of Kansas: Proc. Amer. Philos. Soc., Vol. 12, pp. 168-170.

——— 1871: Catalogue of the *Pythonomorpha* Found in the Cretaceous Strata of Kansas: Proc. Amer. Ph'los. Soc., Vol. 12, pp. 264-287.

——— 1872: On a New Testudinate from the Chalk of Kansas: Proc. Amer. Philos. Soc., Vol. 12, pp. 308-310

——— 1872: On Two New Ornithosaurians from Kansas: Proc. Amer. Philos. Soc., Vol. 12. pp. 420-422.

——— 1872: A Description of the Genus *Protostega*, a Form of Extinct *Testudinata*: Proc. Amer. Philos. Soc, Vol. 12, 422-423.

——— 1872: Description of *Plesiosaurus gulo* and of the Turtle Afterwards Named *Toxochelys latiremis*.

——— 1872: Food of Plesiosaurs: Amer. Nat., Vol. 6, p. 439.

——— 1875: The *Vertebrates* of the Cretaceous Formations of the West: Rep. U. S. Geol. Surv. Terr., Vol. 2, pp. 1-303; 53 plates and 10 wood-cuts, Washington, D. C.

——— 1877: On Some or Little Known Rept'les and Fishes of the Cretaceous No. 3 of Kansas: Proc. Amer. Philos. Soc., Vol. 17, pp. 176-181

——— 1878: Note on Fossils Obtained by Mr. Russell S. Hill, Including Bones of *Protostega gigas*: American Naturalist, Vol. 12, p. 137.

——— 1879: The Necks of the *Sauropterygia*: American Naturalist, Vol. 13, p. 132.

——— 1880: Hill's Kansas Explorations: American Naturalist, Vol. 14, p. 141.

——— 1886: The Long-Spined *Theromorpha* of the Permian Epoch: Amer. Natur., Vol. 20, pp. 544-545

——— 1896: The Reptilia of the Order *Cotylosauria*: Proc. Amer. Philos. Soc., Vol. 34, pp. 436-457, plates VII-IX.

EATON, G. F., 1903: The Characters of *Pteranodon*: Amer. Journ. Sci. (4), Vol. 16, pp. 82-86, plates VI and VII.

——— 1904: Characters of *Pteranodon* (Second Paper); Amer. Journ. Sci. (4), Vol. 17, pp. 318-320, plates XIX and XX.

——— 1908: The Skull of *Pteranodon*: Science (n. s.), Vol. 27, pp. 254-255.

——— 1910: Osteology of *Pteranodon*: Mem. Conn. Acad. Sci., Vol. 2, pp. 1-38, plates I to XXXI.

FRYE, JOHN C., and HIBBARD, CLAUDE W., 1941: Stratigraphy and Paleontology of a New Middle and Upper Pliocene Formation of South-Central Kansas: Journ. Geol., Vol. 49, No. 3 (1941), pp. 261-278.

——— 1941: Pliocene and Pleistocene Stratigraphy and Paleontology of the Meade Masin, Southwestern Kansas: Kans. Geol. Surv. Bull., Vol. 38, Part XIII (1941), pp. 389-424.

GILMORE, C. W. 1921: An Extinct Sea-Lizard from Western Kansas: Scien. Amer., Vol. 124, pp. 273, 280, 3 figs.

——— 1927: The Fossil Lizards of North America: Mem. Nat. Acad. Sci., Vol 22, pp. 1-198, 27 plates and 106 figures.

——— 1930: On dinosaurian reptiles from the Two Medicine formation of Montana: Proc. U. S. Nat. Mus., 77, Art. 16, 1-39.

HAY, O. P., 1905: On the Group of Fossil Turtles Known as the Amphichelydia: with Remarks on the Origin and Relationships of the Suborders, Superfamilies, and Fam'lies of Testudines: Bull. Amer. Mus. Nat. Hist., Vol. 21, pp 137-175, 5 text-figs.

——— 1905: A Revision of the Species of the Family of Fossil Turtles Called Toxochelyidae, With Descriptions of Two New Species of *Toxochelys* and a New Species of *Portochelys*: Bull. Amer. Mus. Nat. Hist., Vol 21, pp. 177-185, figs. 1 to 16.

——— 1908: The Fossil Turtles of North America: Carnegie Instn. Wash., Publ. No. 73, i-iv 1-568 pages; plates 1 to 113; 704 text figures.

——— 1917: On a Collection of Fossil Vertebrates Made by Dr. F. W. Cragin in the Equus Beds of Kansas: Univ. Kans. Sci. Bull., Vol. 10, pp. 39-51, with plates I to III.

HIBBARD, CLAUDE W., 1937: An Upper Pliocene Fauna from Meade County, Kansas: Trans. Kans. Acad. Sci., Vol. 40, pp. 239-265, 5 plates and 2 figures.

——— 1939: Notes on Additional Fauna of Edson Quarry, of the Middle Pliocene of Kansas: Trans. Kans. Acad. Sci., Vol. 42, pp. 457-462.

——— 1940: A New Pleistocene Fauna from Meade County, Kansas: Trans. Kans. Acad. Sci., Vol. 43, pp. 417-425, Dec. 23, 1940.

——— 1941: Mammals of the Rexroad Fauna from the Upper Pliocene of Southwestern Kansas: Trans. Kans. Acad. Sci., Vol. 44, pp. 265-313. (See particularly, p. 266).

——— 1944: Stratigraphy and Paleontology of Pleistocene Deposits of Southwestern Kansas: Bull. Geol. Soc. Amer., Vol. 55, pp. 707-754.

LANE, H. H., 1945: New Mid-Pennsylvanian Reptiles from Kansas: Trans. Kans. Acad. Sci., Vol. 47, No. 3, pp. 381-390.

LEIDY, JOSEPH, 1865: Memoir on the Extinct Reptiles of the Cretaceous Formations of the United States: Smithsonion Contribs. to Knowledge, Vol. 14, Art. 6, pp. 1-135, with plates I-XX.

LEONARD, A. B., and FRYE, JOHN C., 1943: Additional Studies of the Sanborn Formation, Pleistocene, in Northwestern Kansas: Amer. Journ. Sci., Vol. 241 (1943), pp. 453-462.

LOGAN, W. N., 1897: The Upper Cretaceous: Kans. Univ. Geol. Surv., Vol. 2, 1897.

MARSH, O. C., 1871: Notice of Some New Fossil Reptiles from the Cretaceous and Tertiary Formations: Amer. Journ. Sci. (3), Vol. 1, pp. 447-459.

——— 1871: Note on a New and Gigantic Species of *Pterodactyl*: Amer. Journ. Sci. (3), Vol. 1, p. 472.

——— 1872: Discovery of Additional Remains of *Pterosauria*, with Descriptions of Two New Species: Amer. Journ. Sci. (3), Vol. 3, pp. 241-248.

——— 1872: Discovery of the Dermal Scutes of Mosasauroid Reptiles: Amer. Journ. Sci. (3), Vol. 3, pp. 290-292.

——— 1872: Notice of a New Species of *Hadrosaurus*: Amer. Journ. Sci. (3), Vol. 3, p. 301.

——— 1872: On the Structure of the Skull and Limbs in Mosasauroid Reptiles, with Descriptions of New Genera and Species: Amer. Journ. Sci. (3), Vol. 3, pp. 448-464, with 4 plates.

——— 1876: Principal Characters of American Pterodactyls: Amer. Journ. Sci. (3), Vol. 12, pp. 479-480.

——— 1884: Principal Characters of American Cretaceous Pterodactyls: Part I. The Skull of *Pteranodon*: Amer. Journ. Sci. (3), Vol. 27, pp. 422-426, pl. XV.

MEHL, M. G., 1936: *Hierosaurus coleii*: A new aquatic Dinosaur from the Niobrara Cretaceous of Kansas: Denison Univ. Bull., Journ. of the Sci. Lab's., 31, 1-20, Pls. I-III.

——— 1941: *Dakotasuchus kingi*, A crocodile from the Dakota of Kansas: Denison Univ. Bull., Journ. of the Sci. Lab's., 36, 47-65, Pls. II and III.

MERRIAM, J. C., 1894: Ueber die Pythonomorphen der Kansas Kreide: Palaeontographica, Vol. 41, pp. 1-39, with 4 plates and 1 text-figure.

MOODIE, ROY L., 1908: The Relationship of the Turtles and Plesiosaurs: Univ. Kans. Sci. Bull., Vol. 4, pp. 319-327.

——— 1911: An Embryonic Plesiosaurian Propodial: Trans. Kans. Acad. Sci., Vol. 23, pp. 95-101, pl. I, 9 text-figs.

——— 1912: The Stomach Stones of Reptiles: Science (n. s.), Vol. 35, pp. 377-378.

MUDGE, B. F., 1866: First Annual Report of Geology of Kansas.

RIGGS, E. S., 1939: A Specimen of *Elasmosaurus serpentinus*: Field Mus. Nat. Hist., Geol. Ser., Vol. 6, No. 25, pp. 385-391, with 3 figures.

——— 1944: A New Polycotylid Plesiosaur; Univ. Kans. Sci. Bull., Vol. 30, Part 1, No. 8, May 15, 1944.

ROMER, ALFRED S., 1925: An Ophiacodont Reptile from the Permian of Kansas: Journ. Geol., Vol. 33, pp. 173-182, 3 figs.

——— 1945: Vertebrate Paleontology: 2nd. ed., University of Chicago Press, 1945.

ROMER, A. S., and PRICE, L. W., 1940: Review of the Pelycosauria: Geol. Soc. Amer., Spec. Papers, No. 68, Dec. 6, 1940.

STERNBERG, CHARLES H., 1908: An armored dinosaur from the Kansas chalk: Trans. Kans. Acad. Sci., 22, 257-258 (1909).

TAYLOR, E. H., 1941: Extinct Lizards from the Upper Pliocene Deposits of Kansas: State Geol. Surv. Kans. Bull. 38: Reports of Studies, Part 5, pp. 165-176, figs. 1-6, July 7.

WELLES, S. P., 1943: Elasmosaurid Plesiosaurs, with Description of New Material from California and Colorado: Mem. Univ., Calif., Vol. 13, No. 3, pp. 125-254, frontis., plates 12-29, and 37 text-figs.

WHITE, T. E., 1940: Holotype of *Plesiosaurus longirostris* Blake and the Classification of the Plesiosaurs: Journ. Pal., Vol. 14, No. 5, pp. 451-467, with 13 figures.

WIELAND, G. R., 1909: A new armored saurian from the Niobrara: Am. Journ. Sci. (4), 27, 250-252, figs. 7 and 7a.

——— 1911: Notes on the armored Dinosauria: Am. Journ. Sci. (4), 31, 112-124.

WILLISTON, S. W., 1890: A New Plesiosaur from the Niobrara Cretaceous of Kansas: Trans. Kans. Acad. Sci., Vol. 12, pp. 174-178, with 2 text-figs.

——— 1891: The Skull and Hind Extremity of *Pteranodon*: Amer. Nat., Vol. 25, pp. 1124-1126.

——— 1891: Kansas Mosasaurs: Science (n. s.), Vol. 18, p. 345.

——— 1892: Kansas Pterodactyls: Part I: Kans. Univ. Quart., Vol. 1, pp. 1-13, plate I.

——— 1893: An Interesting Food Habit of the Plesiosaurs: Trans. Kans. Acad. Sci., Vol. 13, pp. 121-122, with plate.

——— 1893: Kansas Pterodactyls: Part II: Kans. Univ. Quart., Vol. 2, pp. 79-81, with i text-fig.

——— 1893: Kansas Mosasaurs. Part II: Restoration of *Clidastes*: Kans. Univ. Quart., Vol. 2, pp. 83-84, with plate III.

——— 1894: A New Turtle from the Benton Cretaceous: Kans. Univ. Quart., Vol. 3, pp. 5-18, pls. II-IV, with 9 text-figs.

——— 1895: Note on the Mandible of *Ornithostoma*: Kans. Univ. Quart., Vol. 4, p. 61.

——— 1896: On the Skull of *Ornithostoma*: Kans. Univ. Quart., Vol. 4, pp. 195-197, with plate I.

——— 1897: Restoration of *Ornithostoma* (*Pteranodon*): Kans. Univ. Quart., Vol. 6, pp. 35-51, with plate II and 4 text-figs.

——— 1897: A New Plesiosaur from the Kansas Comanche Cretaceous: Kans. Univ. Quart., Vol. 6, p. 57.

——— 1897: On the Extremities of *Tylosaurus*: Kans. Univ. Quart., Vol. 6, pp. 99-102, with pls. IX-XII, 1 text-fig.

——— 1897: Range and Distribution of the Mosasaurs, with Remarks on Synonymy: Kans. Univ. Quart., Vol. 6, pp. 177-185, with plate XX.

The Number of Exceptional Children in Kansas

HOMER B. REED
Fort Hays Kansas State College, Hays.

The problem of this investigation was the discovery of the number of exceptional children in Kansas; that is, the number of children who because of some deficiency or talent are so constituted that they cannot profit maximally from instruction in the regular grades. In the literature these children are usually classified into the following groups: The partially seeing and blind, the hard of hearing and deaf, the crippled (those not able to go to school or in need of special conveyance or furniture because of physical deformity), the delicate of health (those suffering from malnutrition, anaemia, tubercular condition, or heart disease), the speech defectives, the mentally retarded, the epileptics, the mentally gifted, and those with behavior problems. According to studies made by the U. S. Office of Education, 12.4 per cent of school children in the United States are classified as exceptional. If the same percentage holds for Kansas, the number of exceptional children in Kansas is over 58,000.

Except providing schools for the blind and the deaf Kansas does little for the special education of this group, and as a result most of the handicapped ones remain permanently dependent on either relatives or the state for their maintenance; but the majority of them could be made self-supporting by providing special methods of education.

Before an effective solution can be found for the problem of the education of the exceptional child, it is necessary to know how many such children there are in Kansas and how many fall in each group. Then upon the basis of known extra costs for each group we may arrive at a reasonable estimate of the total cost.

We may estimate the number of exceptional children in Kansas either by assuming that Kansas has the same proportion as the average of the United States or by making a first hand investigation of the actual number of exceptional children of a sample population and then estimating the total number on the basis of this sample, or we may do both.

Stated more exactly, the problem of the investigation was to secure a reliable estimate of the number of exceptional school children in Kansas, to list some of their needs, and to secure an estimate of the costs required to educate them.

Two methods were used, one a questionnaire investigation of

Transactions Kansas Academy of Science, Volume 49, No. 3, 1946.

171 schools distributed over 52 counties in the state, and the second a testing survey of all the elementary school children in one county. Both methods have their advantages and disadvantages. The questionnaire method has the advantage that it can be extensive but it has the disadvantage of inaccuracy. The testing method has the advantage of accuracy but the disadvantage of being limited in extent. The testing method also serves as a check against the questionnaire and gives us a basis for making a selective combination of the two.

The Questionnaire

The questionnaire was directed to teachers and made specific inquiry about the number of pupils in their school districts that belonged to each of the categories of exceptional children already named.

The principal questions used and the results obtained are given below. The results are in the form of the percentages of occurrences in the populations studied and the total number of cases in each category. The second figure is based in each case on the total school population in Kansas in 1941, or 471,760.

Table 1.—*Questionnaire On Exceptional Children.*

(Since not all the items in the original questionnaire are included, the numbering is not consecutive.)

	Per cent	No. in State
Physical Deformities:		
2a. How many children are in your school who by reason of physical deformities must have transportation service to school, especially adjusted furniture, or other special facilities?	.21%	991
2b. How many children under 21 years of age are in your district, who because of physical deformities or prolonged disease, cannot attend school?	.21%	991
Visual Defects:		
3. How many children under 21 years of age are in your district who are blind; that is, have no practical use of their eyes or have little or no visual perception?	.04%	188
4. How many pupils in your district and school who see partially but so poorly they cannot be profitably educated in the regular grades?	.28%	1,321
Auditory Defects:		
6. How many children under 21 years of age are in your district who are deaf and dumb, that is, cannot hear and talk?	.09%	425
7. How many children under 21 years of age in your district who have partial hearing but cannot hear well enough to be profitably educated in the regular grades?	.14%	660
Total number of children retarded (high school and grade combined)	1.67%	7,878
Total number of children accelerated (high school and grade combined)	.18%	849
Speech Defects:		
11. How many children are in your school who speak so indistinctly that they can hardly be understood and who usually cannot be understood by a stranger?	2.25%	10,615
12. How many children are in your school who stutter, that is, either repeat the same sound often or hold the same sound before completing a word?	.72%	3,397
Delicate Health Pupils:		
14. How many children in your school are at the point of failure because of delicate health related to malnutrition, heart trouble, anaemia, tubercular condition, lack of energy, undue paleness, short breath, declining appetite, etc.?	1.46%	6,888

Behavior Problems:		
15. How many children are in your school who are serious problems because of temper tantrums, jealousy, dis-obedience, running away, lying, stealing or cruelty?	1.39%	6,557
16. How many children are in your school who are problems because of failure to participate in play and activities with other children?	.81%	3,821
Reading:		
17. How many children are in grades 2 and 3 who have not learned to read, that is, pupils who do not get the meaning from the sentences in the primer and cannot read them orally well enough to convey their thought to another person?	.74%	3,491
18. How many children are there in grades 4, 5, 6, 7, and 8 who usually fail to get the main ideas in the paragraphs assigned to them and who cannot read them orally well enough to convey their thought to others?	6.23%	29,390
Epileptics:		
19. How many children under 21 years of age are in your school district who have fits either occasionally or more or less regularly?	.25%	1,179
Names and addresses of such children:		
TOTAL NUMBER OF EXCEPTIONAL CHILDREN	16.67%	78,641

The Testing Method

As already stated the testing method was applied to all the school children in one county. The county chosen for the purpose was Ellis because it is one of the more populous counties of the state, ranking in the upper third in this respect; it has practically the same proportion of rural and urban people as the state as a whole; it was geographically convenient for the author of this report and his staff; and all the school authorities were willing to cooperate in the project. In one respect Ellis county is not typical of the population of the state as a whole. Somewhat over half of the people are of German descent. This factor is responsible for a language handicap in mastering English on the part of many children, but it was not considered significant in determining the number of exceptional children. It is possible, however, that it may have caused some intelligence scores to be lower than they should have been.

Two kinds of tests were used, individual and group. The purpose of the individual tests was to secure an index of a pupil's health in the height and weight tests, and of the functional efficiency in oral communication. The purpose of the group tests was to secure a measure of an individual's learning capacity, of his efficiency in mastering important school subjects, and of the correct number of the mentally and educationally retarded. It must be thought that the last could be determined by testing only those suspected of low ability, but since low ability has meaning only in relation to the average ability of one's group, we thought it best to test all pupils and not rely on individual judgment and guessing.

A Description of the Tests Used

The individual tests were for height, weight, vision, hearing, and speech. The group tests were for reading comprehension, arithmetic computation, spelling, and mental ability. Height and weight were measured with shoes removed. Visual acuity was measured with the Snellon test types at a distance of twenty feet.

Auditory acuity was measured with an audiometer, Western Electric 6B. This determines the amount of intensity necessary in terms of decibels for producing a just-audible tone. Only the pitch having a frequency of 1,024 cycles was used unless, for some reason, it was inadequate. In a few schools where an electric current was not available use was made of Politzer's Acumeter, an instrument for producing a constant sound of low intensity. Auditory acuity is measured by the distance at which the sound can be heard. Speech was tested by administering ten selected items from the Bryngelson Articulation Test and by either Gray's Oral Reading Paragraphs or by appropriate paragraphs from Durrell's Reading Manual. The pupil was scored for distinctness of articulation, voice intensity, voice quality, stuttering, and such other defects as unclear speech, speech laterality, baby talk, lisping, and use of foreign accent. About twenty minutes were required to give the individual tests to one pupil.

The group tests used were the following: for grade one, a combination of the Pressey First Grade Reading Scale and the Pressey Primary Classification Test (a mental examination); for grade two, a combination of the Pressey Second Grade Attainment Scale and the Detroit Primary Intelligence Test; for the third grade, the Pressey Third Grade Attainment Scale and the Detroit Primary Intelligence Test; for the upper grades, four to eight inclusive, the Henmon-Nelson Test of Mental Ability and three sections from the Modern School Achievement Tests, those on reading comprehension, arithmetic computation, and spelling.

The above named tests were administered during the months of April and May, 1946, to the schools of Ellis County according to a schedule arranged with the county and city superintendents. The testing staff consisted of five examiners trained for the purpose by the author of this report. The chief examiner was Mr. A. J. Robinson, a clinical psychologist. He was assisted by four college graduates who had had previous teaching experience. One of them also had two years of training as a graduate nurse and was skilled in observing deficiencies in health.

After the pupil had completed his formal tests he was called

before the teacher and the chief examiner for an interview and the administration of the oral reading test. The teacher was told in advance what specific questions would be asked about the pupil's health and behavior. During the interview the examiner looked the pupil over for physical defects and symptoms of disease and also observed his conversational speech. After the interview the examiner made a record of the teacher's report and also checked the completeness of the pupil's examination sheet.

After the tests were scored and the results recorded the criteria for choosing those deficiencies which should entitle a child to be classified as exceptional were selected. They were as follows:

Partially seeing and blind.
- A. Less than 1/5 vision (20/100) in both eyes.
- B. 20/200 vision or less in one eye and 20/70 vision or less in better eye after correction.

Crippled.
Teacher's judgment of inability to go to school because of physical deformity or in need of transportation to and from school or special equipment and furniture.

Hard of hearing and deaf.
A hearing loss of 35 or more decibels in both ears.

Delicate of health.
Any health defect reported by teacher and associated with both achievement and educational quotients below 85. All cases of heart trouble, tubercular condition, epilepsy regardless of achievement, when a teacher said that the diagnosis was made by a physician.

Speech defective.
All stutterers and spastic-speech cases appearing under test conditions. Other speech defects were considered only if, in the judgment of the examiner, they interfered seriously with oral communication.

Mentally retarded.
An Intelligence Quotient of 70 and below.

Mentally gifted.
An Intelligence Quotient of 140 and above.

Behavior problems.
All cases of teacher's judgment of child's failure to participate in play. Other reported cases of behavior difficulties were considered only when both achievement quotient and educational quotient were below 85.

Educationally retarded.
An educational quotient of 75 or below but intelligence quotient higher.

The non-industrious.
An achievement quotient of 75 or below and an educational age below grade norm.

Reading problems.
Grades 1, 2, and 3.
Reading age one or more years below mental and also below 7-5 (that is seven years and five months for a reading educational age) in grade 2 and below 8-5 in grade 3.

Grades 4 and 5.
Grades 4 and 5 Reading age must be two or more years below mental and below 9-0 in grade 4 and 10-0 in grade 5.

Grades 6, 7, and 8.
Reading age three or more years below mental and below 10-6 in grade 6, 11-0 in grade 7, and 12-0 in grade 8.

Test Results for Ellis County

The individual and group tests selected were administered to 2,732 pupils, grades 1 to 8 inclusive, in Ellis county. This includes all the schools in the county except two or three small one-teacher schools which had closed before the date set for testing. The test results were tabulated for each pupil and then the number and per cent of pupils falling in each of the categories set up were computed. Table 2 gives the results.

Table 2.—*Per cent and number of handicapped and gifted children in Ellis county according to tests.*

	Per cent	Number
Vision		
A. One or both eyes 20/50 to 20/100	7.25	198
Both eyes less than 20/100	.81	22
B. 20/200 or less in one eye and 20/70 or less in better eye after correction	.37	10
Wearing glasses, both eyes 20/50 to 20/100 or one eye less than 20/100	1.28	35
Hearing		
Loss of 35 decibels or more in one ear	.77	21
Loss of 35 decibels or more in both ears	.95	26
Health defective		
All kinds	7.91	216
Appearance of heart trouble	.35	9
Appearance of TB	.07	2
Epileptics	.22	6
Speech defective		
All kinds	59.15	1,616
Foreign accent	44.87	1,226
Stutterers	1.10	30
Other (unclear speech, lisping, baby talk, speech laterality, speech rigidity, defects in quality and intensity, etc.)	13.91	380
Mentally retarded		
IQ 75 or less	6.19	169
IQ below 70	3.59	98
Behavior defective		
All kinds	15.12	413
Non-participating	.59	16
Mentally gifted		
IQ 140 or more	2.34	64
IQ 150 or more	.66	18
Reading problems not due to mental retardation	2.96	81
Non-industrious, AQ 75 or less, IQ higher, achievement below grade norm	.51	14
Educationally retarded, EQ 75 or less	3.22	88
EQ 75 or less, IQ higher	.59	16

Looking over the table we see that 1,616, or nearly 60 per cent, have one defect or another in speech. Most of these, 1,226, or about 45 per cent of the total, have a foreign or German accent. To illustrate, a child, instead of saying "We have pigs with big teeth," will say "Ve haf picks wit bick teet." Next in frequency are the behavior defective, 413 or 15 per cent. This includes all behavior defects which the teachers thought serious enough to report to the examiner, but so far as the achhievement tests were concerned they had no noticeable effect. However the 16 cases of nonparticipation in play are undoubtedly significant. Third in frequency are health defects, 216 or nearly 8 per cent. These also had no important effect on achievement but the cases of heart trouble, tuberculosis, or epilepsy should be regarded as serious. Three of the epileptics were not in

school and so for them there is no measure of the influence of their condition on their achievement.

Visual difficulties are fourth in frequency, 198 or 7.25 per cent with 20/50 to 20/100 vision in one or both eyes. Most of these can be adjusted by an occulist, and only a small per cent will need assistance from the state. But this is not the case with those having less than 20/100 vision in both eyes, and certainly not with those having 20/200 or less in one eye and 20/70 or less in the better eye after correction. Next in frequency come the mentally retarded. At first we set our criterion for the exceptional cases at 75 IQ or less but changed it to those below 70 when we discovered the percentage to be 6.19. There is no doubt however that an IQ of 75 indicates a serious handicap and that a pupil with that degree of ability is in need of special aids if he is to learn reading, writing, and spelling well enough to use them for practical needs.

Next in frequency come reading problems not due to mental deficiency. The high percentage of these, 2.96, is an additional reason for including them in the group of exceptional children.

Sixth in frequency come the mentally gifted, 64 or 2.34 per cent. Since our leaders come mostly from this group, it is worth while to save them for society by avoiding habits of idleness by the provision of special materials and instruction.

The non-industrious and the educationally retarded as defined here are few in number but that does not mean that they should be overlooked.

After discovering the number of difficulties found in school children it becmes increasingly clear why those that are serious enough to entitle the child to call upon the state for funds in addition to those provided by the usual channels must be greatly restricted. If from the above we select those that are entitled to be exceptional according to the criteria set up and compare them with the results of the questionnaire we have the following percentages:

TABLE 3.

	Questionnaire	Tests
Partially seeing and blind vision in both eyes less than 20/100		.81
20/200 vision or less in one eye and 20/70 vision or less in better eye	.32	.37
Hard of hearing and deaf	.23	.94
Crippled	0.42	
Delicate of health	1.45	
Speech defective (stutterers)	.72	1.10
Mentally retarded	(1.67)	3.59
Epileptic	.25	
Mentally gifted	.18	2.34
Behavior problems	2.20	
Reading problems	6.97	2.96
Non-industrious		.51
Educationally retarded	1.67	3.22

Since there were no standardized tests for cripples, delicate of health, and behavior problems the teacher's judgment was accepted as the most reliable information obtainable under the conditions. The differences between the percentages for the other categories are due largely to differences in the criteria used. In the case of the partially seeing the criterion for teachers was seeing so poorly that the child cannot be profitably educated in the grades, and for the test result it was (A) less than 20/100 vision in both eyes and (B) 20/200 vision or less in one eye and 20/70 or less in better eye after correction. The percentage for criterion B, 0.37, is very close to that for teacher's judgment, 0.32. In case of hearing defects the corresponding criteria were hearing so poorly that the child cannot be profitably educated in the grades and a loss of 35 or more decibles in both ears.

In case of stuttering the criteria were the same in both methods, but teachers often get used to a child's stuttering, fail to notice it, and so do not report it. Then too some children stutter in an oral reading test given by a stranger when they do not do so in conversation with a familiar person. In case of the mentally retarded and the mentally gifted the only usable criterion given in the questionnaire was over-ageness or under-ageness of a certain amount, but for the tests it was IQ below 70 or IQ 140 or above, respectively. The wide disagreements for the mentally gifted, 0.18 per cent for teachers and 2.34 per cent for tests, is not surprising in view of the fact that bright children are seldom given special promotion. Bright or dull they are promoted by age so long as they pass. In case of reading problems the criterion for teachers was inability to get the main ideas in a reading assignment but the tests made possible a discrimination between non-reading due to mental retardation and non-reading due to other causes. Only the latter were called reading problems, although both fail to read. If we combine these two we get a percentage of 6.15 for the tests, a figure that corresponds well with 6.97, the percentage of non-readers according to teacher's judgments.

In case of the educationally retarded the criterion was over-ageness as given in the questionnaire but for the tests it was EQ 75 or below. The questionnaire is not only somewhat more severe than necessary for an EQ of 75 or less but it also requires looking up records and some computation for accurate reporting. No doubt some teachers did not do this and reported only extreme cases that they recalled. Considering the differences in criteria used in the questionnaire and in the test results, we consider the agreement in the percentages obtained by the two methods as good as could be ex-

pected. Where the criteria are nearly the same as in case of stuttering and on non-reading, the agreement is surprisingly close.

Number of Exceptional Children in Kansas According to a Selected Combination of Both the Questionnaire and Testing Methods

Since there were no standardized tests used for the determination of cripples health and behavior problems we shall use the teacher's judgments for those cases. But for the exceptional cases in vision, hearing, speech, mental retardation, reading and mental acceleration we shall use the test results. Upon this basis we secure the per cents and number of cases for Kansas given in Table 4 which also shows the per cents for the United States as a whole.

Table 4.—*Estimated Per Cents and Number of Children for Kansas and Corresponding Per Cents for United States.*

	Per Cent for U.S.[1]	Per Cent for Kansas	Number for Kansas
Partially seeing and blind	.20	.37	1,745
Hard of hearing and deaf	1.50	.95	4,482
Crippled	1.00	.42	1,981
Delicate of health	1.50	1.46	6,888
Speech defective (stutterers)	1.50	1.10	5,189
Mentally retarded	2.00	2.50	11,794
Epileptics	.20	.25	1,179
Mentally gifted	2.00	2.34	11,039
Behavior problems	2.50	2.20	10,379
Total	12.40	11.59	54,676
Reading problems not due to mental deficiency		2.96	13,964
Total	12.40	14.55	68,640

The differences in per cents between Kansas and the United States are due partly to difference in the criteria used and partly to differences in samples of the populations. The only important difference is in the per cent of mentally retarded, 2 per cent in the United States and 3.59 per cent in Ellis County. Attention has already been drawn to the fact that in Ellis county over half of the population is of German descent and that this may be responsible for a language handicap which tended to lower scores.

On the other hand, since the per cent of geniuses, those with an IQ of 140 or more, is 2.34 and since the point which separates geniuses from the rest of the group is 10 IQ points farther from the mean of 100 than is 70, the point which separates the feeble minded from the normal group, we may assume that the true per cent of the mentally retarded from Kansas is somewhere between 2.34 and 3.59. As a conservative estimate we might place it at 2.50. This is 25 per cent higher than the national average, but much lower than the

[1]Elise H. Martins, "Needs of Exceptional Children," Leaflet No. 74, U. S. Government Printing Office, Washington, D. C., 1944.

rate in Ellis county, and too low if the true per cent of geniuses is 2.34.

The present investigation furnishes no evidence for believing that the true per cent of exceptional children in Kansas is less than for the United States.

What Are Some of the Unusual Educational Needs of Exceptional Children?

If a child cannot distinguish an object at 20 feet which another child sees clearly at 200 feet, it is obvious that if such a child is to read books, he must have unusually large sized print. Anther skill that he should acquire is reading Braille. Books with large print and Braille records are expensive and such expense is higher than that required for normal children. What is true of the near blind is also true of the other types of exceptional children. The following outline gives a summary of the most important needs of exceptional children.

Blind and Partially Seeing
- Blind
  - Tactile methods
  - Braille instruction
  - Special appliances
  - Surgery in some cases
- Partially seeing
  - Special types of glasses and medical service
  - Standard physical surroundings
  - Reading material in large print and other sight saving equipment

Deaf and Hard of Hearing
- Deaf
  - Ear surgery in some cases
  - Special training in developing language concepts
  - Special training in lip reading and speech
  - Aid in forming social contacts
  - Vocational guidance suitable to deaf
- Hard of hearing
  - Ear surgery in some cases
  - Hearing aids
  - Training in speech and in lip reading
  - Stimulation of residual hearing

Crippled
- Surgical care
- Physiotherapy
- Occupational therapy
- Transportation
- Special furniture and equipment
- Home or hospital teaching in some cases

Delicate of Health
- Medical attention
- Individual health program
- Special equipment for health needs
- Home or hospital teaching in some cases

Speech Defective
- Individual attention and corrective exercises
- Oral surgery in some cases
- Transportation to training center if needed
- Guidance in social contacts

Mentally Retarded
- Psychological study
- Adjusted curriculum
- Individual teaching
- Special equipment and material for developing manual skills

Mentally Gifted
- Enriched curriculum
- Special programs for being kept busy
- Training in leadership

Behavior problems
- Psychological study
- Guidance
- Setting up of controls

Reading Problems
- Selected curriculum
- Individual teaching

Epileptics
- Medical care
- Adjusted curriculum
- Facilities for isolation when needed
- Home and hospital instruction in some cases

What Is the Extra Cost of Educating Exceptional Children?

According to Elise H. Martens, who is a specialist in the education of exceptional children in the U. S. Office of Education, the extra cost of educating certain types of exceptional children is as follows:

"TO educate a partially seeing child living at home costs 2.3 times as much as it does to educate a normal child.
TO educate a deaf or seriously hard-of-hearing child living at home costs 2.8 times as much as it does to educate a normal child.
TO educate a crippled child living at home and needing special facilities costs 3.3 times as much as it does to educate a normal child.
TO educate a mentally retarded child living at home costs 1.5 times as much as it does to educate a normal child."

We observe that these costs are much lower than the costs for educating corresponding cases in the state institutions of Kansas, such as the School for the Blind and the School for the Deaf, in which the cost is six to seven times as high as that of the normal child. This is because the estimates of Martens are based on the assumption of children living at home. We also observe that no estimates are given for epileptics, the mentally gifted, behavior problems, reading problems or the delicate of health. We may assume the extra cost for the mentally gifted, the delicate of health, the speech defective, and the epileptics is the same as for the mentally retarded, and that for reading and behavior problems it is at least ten dollars per year per child. Allowing $100 a year as the average annual cost of educating a normal child in the elementary schools of Kansas,

the estimated extra costs of educating the exceptional children of Kansas are as follows:

TABLE 5.—*Estimated Number of Exceptional Children in Kansas and Extra Costs of Educating Them.*

1,745	partially seeing and blind	@	$130	$ 226,850
4,482	hard of hearing and deaf	@	180	806,760
1,981	cripples	@	230	455,630
6,888	delicate of health	@	50	344,400
5,189	speech defectives	@	10	259,450
11,794	mentally retarded	@	50	589,700
1,179	epileptics	@	50	58,950
11,039	mentally gifted	@	50	551,950
10,379	behavior problems	@	10	103,790
13,964	reading problems	@	10	139,640
				$3,537,120

It will be seen that the total estimated cost is a major budget item comparable with other major items in the state budget for Kansas. In 1944 these major items and appropriations were as follows:

County and township roads	$3,600,000
Departments, boards, commissions, and miscellaneous funds wholly or partially supported from the General Revenue Fund	2,399,516
Educational institutions and experiment stations under the Board of Regents	3,988,895
Penal institutions under the State Board of Administration	881,664
Charitable institutions under the State Department of Social Welfare	2,349,603
Patriotic institutions under the Board of Managers	200,000

Like the item for educational institutions, an appropriation for the training of exceptional children, would be regarded as an investment which in later years would repay to the state and nation many times its cost. As an investment it would be very different from the expenditure for charitable and penal institutions which is pure expense and for the most part offers no returns except an easy conscience to the people. If the expenses could be avoided by failure to make an appropriation, that would be an important consideration for the taxpayer, but unfortunately the cost cannot be avoided. If the handicapped children are not trained to be self-supporting, most of them will eventually become charges either for the charitable or for the penal institutions. From a business standpoint it is better to train children to become independent than it is to allow them to become more expensive by letting them lapse into indigence or crime. The possibility of great returns from extra expenditure for the mentally gifted should not be overlooked. Kansas probablly has its greatest natural resource in its 11,000 gifted children. All of them have IQ's equal to or greater than those computed for many of the famous men in history such as Cervantes, Copernicus, Oliver Goldsmith, Robert Burns, George Washington, Abraham Lincoln, Henry Ford, and Charles Darwin. With opportunities for developing their talents these gifted children might in many cases equal or excel the

performances of these great men and make equal contributions to their country.

Summary

The methods used in this investigation yield an estimate of 68,640 exceptional school children in Kansas, or 14.55% of the school population. The estimated annual extra cost of giving these children a special education is three and one-half million dollars. It would require some years to develop a full program requiring this amount. However, the program could be started with a comparatively small amount.

Application of the Electronic Theory to Some Simple Organic Reactions. II.[1]

C. A. VANDER WERF
University of Kansas, Lawrence.

Application of the electronic theory to a study of the simple reactions of the alcohol and the ether functions makes possible a method of correlation and a degree of systematization which are lacking in the classical treatment of these homologous series. In the present paper, an attempt is made to suggest how the electronic theory may serve as the basis for the study of some of the characteristic reactions of these two functional groups.

The Alcohol Function

The chemical behavior of alcohols is best understood if alcohols are considered to be, like water, both acidic and basic. In the alcohols, the primary electron displacement is the $-I_s$[2] effect of the oxygen atom. The pair of electrons constituting the bond between the oxygen atom and the hydrogen atom is shifted toward the highly electronegative oxygen atom, and away from the hydrogen atom. A similar shift toward the oxygen atom and away from the carbon atom characterizes the bonding electron pair between the oxygen atom and the carbon atom to which it is joined. These effects may be represented in an exaggerated fashion by the type formula

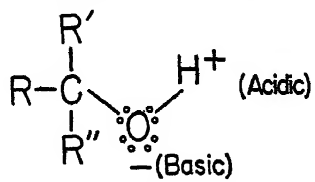


FIG. 1

in which R, R′, and R″, respectively, may represent a hydrogen atom or an alkyl group. Because the angle which the two valence bonds of the oxygen atom make with each other is not 180°, but in most alcohols is found to be approximately 108°, these electron displacements lead to the existence of a permanent dipole moment in the molecule. Furthermore, an alcohol molecule, like that of water, is permanently activated with the oxygen atom a center of high electron density, *i.e.*, a basic center, and the hydrogen atom a center of low electron density, *i.e.*, an acid center.

In any comparison of the relative acidity or basicity of the alcohols with that of water, or of the various classes of alcohols with

each other, it is the relative electronegativity of the atom or radical attached to the hydroxyl group which is the determining factor. Consider, for example, the general formula YOH, where Y may represent either a hydrogen atom or an alkyl group. If Y is highly electronegative, as compared with hydrogen, its effect will be to decrease the electron density about the hydroxyl group thereby weakening the basic properties of the oxygen atom and strengthening the acid properties of the hydrogen atom in the molecule as compared with those in water. If, on the other hand, Y is very weakly electronegative, it will exhibit a strong +I effect toward the hydroxyl group, and the resulting high electron density about that group will manifest itself in an increased basicity and a decreased acidity for the compound YOH, as compared with water.

Inasmuch as a hydrogen atom is more electronegative than an alkyl group, it would be predicted on the basis of the foregoing discussion, that alcohols are, in general, more basic and less acidic than water. The electronegativities of the three general classes of alkyl groups decrease in the order P>S>T, where P, S, and T represent primary, secondary, and tertiary alkyl groups, respectively. Hence, primary, secondary, and tertiary alcohols would be expected to decrease in acidity and to increase in basicity in that order. These predictions may be summarized as follows:

Order of increasing electron density on O-atom and of increasing basicity
$$\xrightarrow{\hspace{20em}}$$
HOH POH SOH TOH
$$\xleftarrow{\hspace{20em}}$$
Order of decreasing electron density on H-atom and of increasing acidity

It is well known that water molecules are extensively associated through the formation of hydrogen bonds. This behavior is explained on a theoretical basis by the assumption that the electron density about the hydrogen atoms in water is sufficiently low, *i.e.*, that the hydrogen atoms are sufficiently acidic, to cause the hydrogen atoms in any given water molecule to exhibit a marked tendency to accept a share in an unshared electron pair about an oxygen atom in a second water molecule. This process may, of course, continue in several steps, to lead to the formation of such associated molecules as H_4O_2, H_6O_3, H_8O_4, $H_{10}O_5$, etc. Such physical properties as the melting point, the viscosity, the heat of vaporization, and especially the boiling point of water are all unusually high because of the extensive association of water molecules. The fact that the boiling point, for example, of water is abnormally high will become apparent at once to anyone who attempts to recall a second covalent compound

having a molecular weight of 18 or less which has a boiling point of 100° C. or over.

Like water, the alcohols, because of the acidity of the hydroxyl-hydrogen atom, are also highly associated in the liquid state. It is not surprising, therefore, that the boiling point, melting point, density, viscosity, and heat of vaporization of a given alcohol are considerably higher than the corresponding properties of a hydrocarbon of equal molecular weight. It would be predicted, however, that association in the simple alcohols should be considerably less extensive than in water, both because of the decreased acidity of the alcohols as compared with water, and because of the fact that the molecule of a monohydric alcohol has only a single hydrogen atom capable of forming hydrogen bonds. This prediction is verified by a comparison of the physical constants of water and the alcohols. Methyl alcohol, for example, has a molecular weight almost double that of water, but its boiling point is 35.3° C. lower than that of water, and its melting point, density, viscosity, and heat of vaporization are likewise considerably lower than the corresponding values for water.

It is interesting to observe that a study of the physical properties of the various alcohols indicates that the degree of association among the various classes of alcohols decreases in the same order as the acidity, namely, POH>SOH>TOH. Thus the boiling points, for example, of isomeric alcohols decrease in the order POH>SOH>TOH.*
In the case of the butyl alcohols, the values are 117° C., 99.5° C., and 82.9° C. for the primary, secondary, and tertiary alcohols, respectively.

As a result of the dual character of the alcohols, most of the chemical reactions of the members of this homologous series may be divided into two classes: (1) the acid reactions and (2) the basic reactions. The first class includes those reactions in which the hydroxyl-hydrogen atom is removed from the alcohol molecule in such a way that both electrons of the pair which constitutes the bond between it and the oxygen atom are retained by the oxygen atom. Any specific reaction of this type should proceed most rapidly in the case of water, next rapidly in the case of primary alcohols, and most slowly for secondary and, finally, tertiary alcohols. This order of decreasing rate of the acid reactions may be summarized as follows: HOH>POH>SOH>TOH.

*This phenomenon may be due in part simply to the effect resulting from a branching of the hydrocarbon chain.

An excellent example of the acid reactions of alcohols is their behavior toward an active metal, such as sodium. Water reacts vigorously with sodium, primary alcohols considerably more slowly, and secondary and tertiary alcohols rather sluggishly. In fact, the common qualitative test for primary, secondary, and tertiary alcohols on the basis of the rates of their reactions with sodium is actually based on the relative *acidities* of the three classes of alcohols.

The same order of acidities is clearly indicated by the reactions of the conjugate bases of water and of the various types of alcohols. The strongest bases are, of course, those whose conjugate acids are weakest. It is apparent, once again, from reactions (all of which proceed far to the right) such as those indicated by the following equations, that the acidity of water and the alcohols decreases in the order HOH>POH>SOH>TOH:

$$\mathrm{HOH} + \mathrm{PO}^- \rightleftarrows \mathrm{POH} + \mathrm{OH}^-$$
$$\mathrm{POH} + \mathrm{SO}^- \rightleftarrows \mathrm{SOH} + \mathrm{OH}^-$$
$$\mathrm{SOH} + \mathrm{TO}^- \rightleftarrows \mathrm{TOH} + \mathrm{OH}^-$$

The basic reactions of the alcohols, which we have listed as class (2) are those in which the oxygen atom shares one of its unshared electron pairs with an electron acceptor (Lewis acid) or in which the hydroxyl group is removed from the alcohol molecule in such a way that the oxygen atom retains both electrons of the pair binding it to the carbon atom. For any such reaction it would be predicted that the rate would decrease in the order of decreasing basicity: TOH>SOH>POH.

The marked solubility, as compared with the hydrocarbons, of the lower alcohols in water is considered to result from the basic reaction of the alcohol molecule in which the oxygen atom shares an electron pair with a hydrogen atom of the more acidic water molecule to form a hydrogen bond:

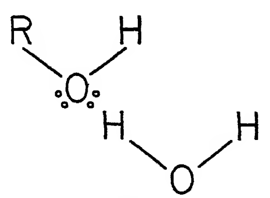


FIG. 2

In the case of isomeric alcohols, the solubility decreases in the expected order: TOH>SOH>POH. In the higher alcohols, the bulky alkyl groups interfere with this process of co-association, and

the solubility of the compounds in water is decreased sharply. All higher alcohols are, however, soluble in strong acids such as concentrated sulfuric acid because of the fact that they are sufficiently basic to react with such acids to form oxonium compounds:[8]

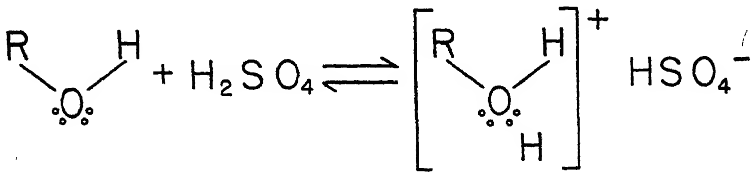


FIG. 3

This latter reaction constitutes the initial step in many of the familiar reactions of the alcohols such as partial dehydration in the presence of sulfuric acid to form ethers or complete dehydration to form olefins, or such as the formation of alkyl hydrogen sulfates with sulfuric acid or of alkyl halides with the hydrogen halides. It is assumed that in all reactions of this type the oxonium ion, which is formed in the cold upon the addition of the acid, decomposes upon heating to form water and a highly reactive carbonium[1] ion:

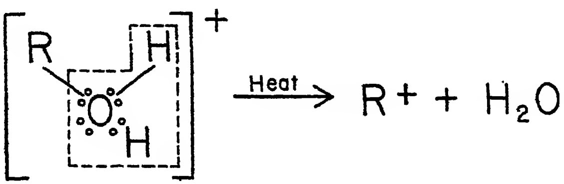


FIG. 4

This step illustrates the second type of basic reaction of the alcohols, namely that in which the hydroxyl group is split off, the oxygen atom retaining both electrons of the pair it originally shared with the carbon atom. The resulting carbonium ion, which is in every case a strong Lewis acid, may undergo any of a number of reactions, depending upon the temperature and the relative concentrations of various bases with which it may potentially react. At high temperatures, the carbonium ion may lose a proton to the conjugate base of the acid which was added, to form an olefin. At lower temperatures, it may coordinate with the conjugate base to form an alkyl hydrogen sulfate (in the case of sulfuric acid) or an alkyl halide (in the cases of the hydrogen halides). In the presence of a large excess of alcohol, it may coordinate the alcohol to give an ether (in the form of its oxonium ion) or, in the presence of large

amounts of water, it may coordinate water to regenerate the oxonium ion of the alcohol.

Most of these reactions can be effected by the use of a Lewis acid in place of a Brönsted acid. The Lewis acid, aluminum oxide, for example, is an excellent catalyst for the production of olefins or of ethers from alcohols. The reactions are initiated, in this case, by the formation, not of an oxonium ion, but of an alcoholated aluminum oxide unit, in which the aluminum, with its unfilled electron shell, accepts a share in an unshared electron pair of the alcohol oxygen atom. In the second step of these reactions, the hydroxyl group is split from the alcohol leaving a carbonium ion which may then participate in any of the several reactions described previously. Similarly, the first step in the reactions of alcohols with the phosphorus halides, which are also Lewis acids, is thought to be the coordination of the alcohol molecule about the pohsphorus atom, through an unshared electron pair of the alcohol oxygen atom. The reaction of water with the phosphorus halides is, of course, completely analogous to those of the alcohols, and serves to emphasize the fact that water, like the alcohols, may function as a base as well as an acid.

In all of the basic reactions of the alcohols, the rates of reaction decrease in the order TOH>SOH>POH. The familiar Lucas test[4] for distinguishing among primary, secondary, and tertiary alcohols on the basis of the rate of the formation of the alkyl chloride when the alcohol is treated with zinc chloride and concentrated hydrochloric acid, is actually based on the fact that tertiary alcohols are more basic than secondary alcohols, which, in turn, are more basic than primary alcohols. It is interesting to note that the formation of the alkyl chloride is indicated by the appearance of two layers; the original alcohol, being a base, is soluble in the acid medium, but the resulting alkyl halide, which is not basic, is insoluble. For a given alcohol, the rates of reaction with the hydrogen halides, as would be expected, becomes more rapid as the strength of the acid increases: HI>HBr>HCl>HF. The ease with which tertiary and, to a lesser extent, secondary alcohols are dehydrated is well known.

A most interesting reaction in which the alcohols combine their basic and acidic functions is that of esterification. Esterification reactions are probably initiated by the coordination of the alcohol molecule about the electron deficient carboxyl-carbon atom in the activated form of the acid molecule (I). In this step, the alcohol

acts as a base. The esterification reaction cannot be completed, however, until the alcohol loses a proton which combines with the hydroxyl group from the acid to form a molecule of water (II).

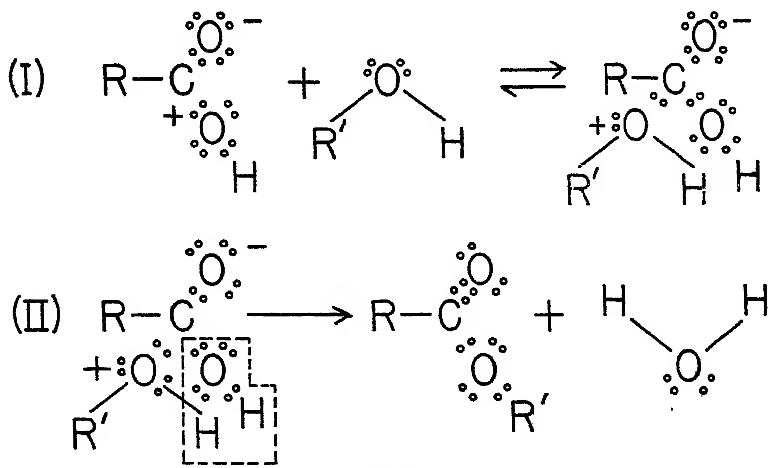


FIG. 5

Here the alcohol exhibits its acid function. It is thought that the second step must be the rate-controlling one, as the rate of esterification of alcohols decreases in the order POH>SOH>TOH. Interpreted in terms of the actual mechanism, this implies that of the total number of alcohol molecules which are coordinated about a carboxyl-carbon atom at any given moment, only a small fraction proceed to lose a proton to complete the esterification reaction; most of the total number simply break away to re-form the original alcohol and acid molecules (reverse of reaction (I)).

The Ether Function

Lacking the acid hydrogen atom which characterizes the alcohols, the ethers do not exhibit the acid reactions of the alcohols. They do not, for example, react with active metals such as sodium, nor do they ordinarily undergo esterification reactions with organic acids. Their physical properties are characteristically those of polar covalent compounds whose molecules are incapable of association.

On the other hand, the ethers retain the basic oxygen atom characteristic of the alcohols, and therefore undergo all the common basic reactions of the alcohols. The lower ethers are soluble in water, as would be predicted from the fact that ether molecules can co-associate with water molecules. The hydrogen bonds formed in such co-association must, of course, involve the oxygen atom of the

ether molecules and the hydrogen atoms of the water molecules. The higher ethers, although insoluble in water, dissolve in strong acids to form oxonium compounds.[5] In fact, the simplest test for distinguishing between saturated hydrocarbons and ethers depends upon the fact that the latter compounds, unlike the hydrocarbons, are basic, and are therefore soluble in concentrated sulfuric acid. When heated with strong Brönsted acids, such as sulfuric or hydriodic acid, or with Lewis acids, such as phosphorus pentachloride, the ethers react according to the same mechanism as do the alcohols, to form alkyl hydrogen sulfates or alkyl halides. In general, it may be said that for a given ether the rates of reaction with different acids becomes more rapid as the strength of the acid increases. Thus for the hydrogen halides the rates decrease in the order HI > HBr > HCl > HF. With the Lewis acid aluminum oxide, at elevated temperatures, ethers, like alcohols, are dehydrated to form olefins.

Literature Cited

(1) First paper in this series: Vanderwerf, these *Transactions*, 48, 91 (1945).
(2) Vanderwerf and Sisler, these *Transactions*, 47, 89 (1944).
(3) Lucas, *Organic Chemistry*, American Book Company, 1935, page 124.
(4) Shriner and Fuson, *The Systematic Identification of Organic Compounds*, John Wiley and Sons, Inc., 2nd ed., 1940, pages 55-56.
(5) Remick, *Electronic Interpretations of Organic Chemistry*, John Wiley and Sons, Inc., 1943, page 33.

Comparison of the Scores of Design Engineering Personnel with Factory Workers on the MacQuarrie Mechanical Performance Ability Tests

IRVIN T. SHULTZ
Baylor University, Waco, Texas. Formerly at Friends University, Wichita.

The success of any instrument for personal research in industry depends upon the accuracy with which it can differentiate qualitatively and quantitatively abilities for particular job requirements. The MacQuarrie Test for Mechanical Ability, published by the California Test Bureau, is a paper and pencil test composed of seven subtests, as follows:

Test I is a tracing test which measures eye-hand-arm-coordination. The individual, using a sharp pencil, must "pass" a small opening in a vertical line quickly and accurately.

Test II is a tapping test designed to test speed primarily, accuracy secondarily.

Test III is a dotting test requiring accuracy in finger dexterity with hand and eye coordination.

Test IV is a copying test in which the subject is asked to reproduce an angular design having only two dimensions.

Test V is a location test calling for the ability to see reductions in size and to distribute attention between a large rectangle and a smaller one. It, too, involves only two-dimensional spatial relations.

Test VI is a block test requiring the subject to determine how many blocks, in a picture of a pile of blocks, touch each block indicated on the diagram. The blocks of the diagram are long and narrow, but the subject is told they are of the same size.

Test VII is a pursuit test in which the individual is required to follow a curving line through a maze of other lines and find its ultimate ending in a column at the right. It is largely a test of eye coordination in difficult situations.

The total score of the MacQuarrie test is an arbitrary sum of the total score divided by three. It was not used in these calculations because its internal pattern was more needed for the analysis than any arbitrary total score. The problem here presented is, briefly: To what extent does the MacQuarrie test reveal significant differences between a group of nineteen engineers, who were employed for designing and research, and one-hundred-thirty-eight factory workmen employees of the Coleman Company of Wichita, Kansas?

The group referred to in this study as workmen were selected

from fourteen different types of jobs in as many departments on a best-worst basis. That is, these workmen demonstrated a continuous unimodal normal distribution from the best through to the worst. The other group designated in this study as the engineering group worked at the following levels: four were design engineers, college engineering graduates; one was head of a research group; one was head of the laboratory; one was head of a group of model makers; four were design draftsmen; four were laboratory technicians, and four were model makers. These men represented a homogenous group to the extent that they work together in teams, and do various phases of the same general work, which is to design the company's new products and test models of the same.

Table I gives the actual differences of the means of the two groups, the sigma differences, and the critical ratios, which must be three or more to indicate an absolute difference between the groups.

TABLE I

	Test I Tracing	*Test II* Tapping	*Test III* Dotting	*Test IV* Copying	*Test V* Location	*Test VI* Blocks	*Test VII* Pursuit
Actual Diff. of Means	4.2	6.9	2.1	19.5	6	4.5	3.8
Sigma Diff.	1.8	1.6	.73	3.8	1.7	1.5	1.3
Critical Ration	2.3	4.3	2.9	5.1	3.5	3.0	2.9

An inspection of these critical ratios determines the extent of the differences among the subtests with reference to the enginering group and the workman group. It is noted that there is a large statistically reliable difference between the groups on Test IV—Copying, V—Location, VI—Blocks, and a close approach to significance on Test VII—Pursuit. Harrell (1939)[8] studied the relationships between thirty-four tests which were applied to ninety-one cotton-mill machine fixers in Georgia. From a centroid analysis five factors appeared, of which one was called "visualization," a factor which required that one would imagine how things would look when put together, or rotated in two or even three dimensional planes. This one factor, visualization or spatial imagery plus reasoning, was found to be most heavily loaded (pure) in these four MacQuarrie tests.

The large critical ratios of Test II—Tapping, particularly, and the somewhat smaller but almost significant ratio of Test III—Dotting, MacQuarrie tests of motor coordination, might compare favorably with the factor labeled manual dexterity in the Harrell study. The study is referred to in Greene, E. B., "Measurements of Human Behavior," Odessy Press, 382-385.

Results and Conclusions

1. The MacQuarrie Test is a valid instrument for measuring visualization and manual dexterity abilities, which differentiate engineers and factory workmen herein described.

2. The ability labelled spatial imagery or visualization seems to be the most definite and distinct in the last four MacQuarrie subtests.

3. Manual dexterity or motor coordination is also evidenced by two of the tests, tapping and dotting.

4. These two abilities are necessary for engineering.

5. The MacQuarrie Test is valid when combined with other tests and techniques for selection of engineering personnel.

Bibliography

(1) Garrett, H. E., "Statistics in Psychology and Education," New York, Longmans, 1938.
(2) Greene, E. B., "Measurements of Human Behavior," New York, Odessy Press, 1943, 382-384.
(3) Harrell, W., "A Factor Analysis of Mechanical Ability Items," Psychological Bulletin, 1939, 36-524.

Birds of Kerr County, Texas

HELMUT K. BUECHNER
Texas Cooperative Wildlife Research Unit and Department of Fish and Game, Agricultural and Mechanical College of Texas, College Station, Texas.

Kerr County appears to be on a dividing line between many eastern and western forms of bird life. It is situated on the Edwards Plateau, which is the southern termination of the Great Plains in central Texas. Approaching from the east, the Edwards Plateau is the first abrupt rise in elevation encountered. The rise extends north through central Texas as the so-called "first plateau". The change occurs at the Balcones Escarpment, a Cretaceous fault line that extends roughly from Dallas through Waco and Austin to San Antonio, and then westward to Del Rio. Elevations within Kerr County range from 1,000 to 2,300 feet. The topography varies from the level alluvial lands along the Guadalupe River to the hilly lands in the uplands. Drainage is principally by the Guadalupe River and its tributaries, although the Frio, Sabinal, Medina, and South Llano rivers also have their headwaters in the county.

The deep alluvial soils of the Guadalupe Valley are utilized for cultivation; the thin limestone soils of the uplands for livestock grazing. River bottoms support heavy stands of cypress, water oak, hackberry, pecan, and walnut; whereas the dry uplands are covered by oak-savannah pastures, cedar brakes, and dense thickets of "shinnery" oak.

The present bird list is based primarily upon specimens in the Texas Cooperative Wildlife Collection at the Agricultural and Mechanical College of Texas, and the following collections as indicated in the United States Fish and Wildlife Service records: Biological Survey, L. B. Bishop, Colorado Museum of Natural History, the Jonathan Dwight Collection, Field Museum of Natural History, Museum of Comparative Zoology, Princeton, R. W. Quillin, L. C. Sanford, and J. E. Thayer. These specimens were supplemented by information contained in Howard Lacey's "Birds of Kerrville, Texas and Vicinity" (Auk, vol. 28, no. 2, pp. 200-219, 1911), and "Additions to the Avifauna of Kerr County, Texas" by Austin Paul Smith (Auk, vol. 33, no. 1, pp. 187-193, 1916), together with sight records and notes by D. W. Lay, B. E. Ludeman, T. F. Smith, R. R. Ramsey, F. B. Armstrong, P. S. Van Dyke, and W. P Taylor. The Texas Cooperative Wildlife Research Unit,[1] under the direction of Dr.

Transactions Kansas Academy of Science, Volume 49, No. 3, 1946.

[1]The Fish and Wildlife Service (United States Department of the Interior), the Agricultural and Mechanical College of Texas (research, extension, teaching), the Texas Game, Fish and Oyster Commission, and the American Wildlife Institute, cooperating.

W. P. Taylor, has made possible the collection of specimens, sight records, and notes upon which this report is largely based.

The author accepts credit only for compiling the material from the above sources. The records at the United States Fish and Wildlife Service were examined personally, as well as specimens in the Biological Survey Collection in Washington, D. C.

Dr. H. C. Oberholser, of the Cleveland Museum of Natural History, has been kind enough to check the identifications of most specimens. An asterisk preceding the name of a bird indicates that the specimens have been verified by Oberholser.

Permanent Residents

Individual birds of the permanent residents may move to and from the area seasonally, being more abundant at some seasons than others, but the species is thought to be represented in the county throughout the year. Numbers following the names of species indicate relative abundance, "1" being rare, "2" occasional, "3" not uncommon, and "4" common.

Treganza Heron (*Ardea herodias treganzai*). 2
*Eastern Green Heron (*Butorides virescens virescens*). 2
Western Turkey Vulture (*Cathartes aura teter*). 4
Black Vulture (*Coragyps atratus atratus*). 4
*Cooper Hawk (*Accipiter cooperi*). 1
*Fuertes Red-tailed Hawk (*Buteo jamaicensis fuertesi*). 3
Northern Red-shouldered Hawk (*Buteo lineatus lineatus*). 1
*Texas Bobwhite Quail (*Colinus virginianus texanus*). 3
*Rio Grande Turkey (*Meleagris gallopavo intermedia*). 4
American Coot (*Fulica americana americana*). 1
*Killdeer (*Oxyechus vociferus vociferus*). 3
*Western Mourning Dove (*Zenaidura macroura marginella*). 4
Inca Dove (*Scardafella inca inca*). 3
*Road-runner (*Geococcyx californicus*). 2
Barn Owl (*Tyto alba pratincola*). 1
*Hasbrouck Screech Owl (*Otus asio hasbroucki*). 3
*Great Horned Owl (*Bubo virginianus virginianus*). 2
Texas Barred Owl (*Strix varia helveola*). 2
*Nuttall Poor-will (*Phalaenoptilus nuttalli nuttalli*). 2
*Ruby-throated Hummingbird (*Archilochus colubris*). 1
*Eastern Belted Kingfisher (*Megaceryle alcyon alcyon*). 3
Texas Green Kingfisher (*Chloroceryle americana septentrionalis*). 2
*Golden-fronted Woodpecker (*Centurus aurifrons*). 1
*Texas Woodpecker (*Dryobates scalaris symplectus*). 3
*Eastern Phoebe (*Sayornis phoebe*). 3
*Vermilion Flycatcher (*Pyrocephalus rubinus mexicanus*). 4
*Texas Jay (*Aphelocoma californica texana*). 3
*Southern Crow (*Corvus brachyrhynchos paulus*). 1
*Plumbeous Chickadee (*Penthestes carolinensis agilis*). 4
Tufted Titmouse (*Baeolophus bicolor*). 2
*Sennett Titmouse (*Baeolophus atricristatus sennetti*). 4
*Lead-colored Bush-tit (*Psaltriparus minimus plumbeus*). 4
*White-breasted Nuthatch (*Sitta carolinensis carolinensis*). 2
*Texas Wren (*Thryomanes bewicki cryptus*). 4
*Carolina Wren (*Thryomanes ludovicianus ludovicianus*). 4
*Canyon Wren (*Catherpes mexicanus conspersus*). 3

*Western Mockingbird (*Mimus polyglottos leucopterus*). 4
*Eastern Bluebird (*Sialia sialis sialis*). 4
Starling (*Sturnus vulgaris vulgaris*). 2
*English Sparrow (*Passer domesticus domesticus*). 3
*Louisiana Cowbird (*Molothrus ater buphilus*). 3
*Gray-tailed Cardinal (*Richmondena cardinalis canicauda*). 4
*House Finch or Linnet (*Carpodacus mexicanus frontalis*). 4
*Canyon Towhee (*Pipilo fuscus texanus*). 2
*Western Lark Sparrow (*Chondestes grammacus strigatus*). 3
*Rock Sparrow (*Aimophila ruficeps eremoeca*). 2
*Western Chipping Sparrow (*Spizella passerina arizonae*). 3
*Eastern Field Sparrow (*Spizella pusilla pusilla*). 4

Winter Residents

This list includes birds occurring only in fall, winter, and early spring. None of them is known to breed here.

*Pied-billed Grebe (*Podilymbus podiceps podiceps*). 2
Common Mallard (*Anas platyrhynchos platyrhynchos*). 3
Gadwall (*Chaulelasmus streperus*). 2
Baldpate (*Mareca americana*). 2
*American Pintail (*Dafila acuta tzitzihoa*). 3
Green-winged Teal (*Nettion carolinense*). 2
*Blue-winged Teal (*Querquedula discors*). 2
*Ring-necked Duck (*Perissonetta collaris*). 3
*Canvas-back (*Aristonetta valisineria*). 2
Lesser Scaup Duck (*Fulix affinis*). 2
*Sharp-shinned Hawk (*Accipiter striatus velox*). 3
*Western Goshawk (*Accipiter gentilis striatulus*). 1
Golden Eagle (*Aquila chrysaetos canadensis*). 1
Marsh Hawk (*Circus cyaneus hudsonius*). 1
*Sparrow Hawk (*Cerchneis sparveria sparveria*). 3
*Wilson's Snipe (*Capella gallinago delicata*). 1
Spotted Sandpiper (*Actitis macularia*). 2
*Greater Yellow Legs (*Totanus melanoleucus*). 1
*Northern or Yellow-shafted Flicker (*Colaptes auratus luteus*). 3
*Red-shafted Flicker (*Colaptes cafer collaris*). 2
*Yellow-bellied Sapsucker (*Sphyrapicus varius atrothorax*). 2
Red-headed Woodpecker (*Melanerpes erythrocephalus erythrocephalus*). 1
*Yukon Phoebe (*Sayornis saya yukonensis*). 2
Tree Swallow (*Iridoprocne bicolor*). 1
Barn Swallow (*Hirundo rustica erythrogaster*). 1
*Brown Creeper (*Certhia familiaris americana*). 2
*Western House Wren (*Troglodytes domesticus parkmani*). 1
Eastern Brown Thrasher (*Toxostoma rufa rufa*). 1
*Sage Thrasher (*Oreoscoptes montanus*). 2
*Eastern Robin (*Turdus migratorius migratorius*). 4
*Southern Robin (*Turdus migratorius achrusterus*). 2
*Sierra Hermit Thrush (*Hylocichla guttata sequoiensis*). 2
*Eastern Golden-crowned Kinglet (*Regulus satrapa satrapa*). 2
*Western Ruby-crowned Kinglet (*Corthylio calendula cineraceus*). 4
American Pipit (*Anthus spinoletta rubescens*). 4
*Cedar Waxwing (*Bambycilla cedrorum*). 4
Shrike (*Lanius ludovicianus* ssp.). 3
*California Shrike (*Lanius ludovicianus gambeli*). 1
*Eastern Orange-crowned Warbler (*Vermivora celata celata*). 2
*Rocky Mountain Orange-crowned Warbler (*Vermivora celata orestera*). 1
Eastern Meadowlark (*Sturnella magna magna*). 4
*Western Meadowlark (*Sturnella neglecta neglecta*). 4
*Brewer Blackbird (*Euphagus cyanocephalus cyanocephalus*). 3
*Pine Siskin (*Spinus pinus pinus*). 2
*Eastern Goldfinch (*Spinus tristis tristis*). 4
*Spurred Towhee (*Pipilo maculatus montanus*). 4

Western Savannah Sparrow (*Passerculus sandwichensis alaudinus*). 3
*Western Vesper Sparrow (*Pooecetes gramineus confinis*). 4
*Slate-colored Junco (*Junco hyemalis hyemalis*). 4
Western Field Sparrow (*Spizella pusilla arenacea*). 4
*Harris Sparrow (*Zonotrichia querula*). 2
*Eastern Fox Sparrow (*Passerella iliaca iliaca*). 2
*Lincoln Sparrow (*Melospiza lincolni lincolni*). 3
*Mississippi Song Sparrow (*Melospiza melodia beata*). 2
*Chestnut-collared Longspur (*Calcarius ornatus*). 3

Summer Residents

All of the birds listed here occur only in summer, and are thought to breed in the county.

Little Blue Heron (*Florida caerulea caerulea*). 1
*Yellow-crowned Night Heron (*Nyctanassa violacea violacea*). 1
*Harris Hawk (*Parabuteo unicinctus harrisi*). 2
*Yellow-billed Cuckoo (*Coccyzus americanus americanus*). 3
*Chuck-will's-widow (*Antrostomus carolinensis*). 1
*Whip-poor-will (*Setochalcis vocifera vocifera*). 1
*Cherrie Nighthawk (*Chordeiles minor aserriensis*). 3
*Western Nighthawk (*Chordeiles minor henryi*). 2
*Black-chinned Hummingbird (*Archilochus alexandri*). 3
*Scissor-tailed Flycatcher (*Muscivora forficata*). 4
*Northern Crested Flycatcher (*Myiarchus crinitus boreus*). 2
*Ash-throated Flycatcher (*Myiarchus cinerascens cinerascens*). 4
*Acadian Flycatcher (*Empidonax virescens*). 3
*Alder Flycatcher (*Empidonax trailli trailli*). 1
Eastern Wood Pewee (*Myiochanes virens*). 3
*Western Wood Pewee (*Myiochanes richardsoni richardsoni*). 1
*Lesser Cliff Swallow (*Petrochelidon albifrons tachina*). 3
*Coahuila Cliff Swallow (*Petrochelidon fulva pallida*). 2
*Purple Martin (*Progne subis subis*). 3
Common Rock Wren (*Salpinctes obsoletus obsoletus*). 1
*Blue-gray Gnatcatcher (*Polioptilia caerulea caerulea*). 3
*Black-capped Vireo (*Vireo atricapillus*). 2
*Northern White-eyed Vireo (*Vireo griseus noveboracensis*). 4
*Bell Vireo (*Vireo belli belli*). 2
*Yellow-throated Vireo (*Lanivireo flavifrons*). 3
*Red-eyed Vireo (*Vireosylva olivacea*). 3
*Black and White Warbler (*Minotilta varia*). 3
*Western Parula Warbler (*Compsothlypis americana ramalinae*). 3
*Sonora Yellow Warbler (*Dendroica aestiva sonorana*). 2
*Golden-cheeked Warbler (*Dendroica chrysoparia*). 3
*Sycamore Warbler (*Dendroica dominica albilora*). 2
*Kentucky Warbler (*Oporornis formosus*). 3
*Long-tailed Chat (*Icteria virens longicauda*). 4
*Rio Grande Red-wing (*Agelaius phoeniceus megapotamus*). 2
*Orchard Oriole (*Icterus spurius*). 4
*Bullock Oriole (*Icterus bullocki*). 2
*Summer Tanager (*Piranga rubra rubra*). 4
*Western Blue Grosbeak (*Guiraca caerulea interfusa*). 4
*Indigo Bunting (*Passerina cyanea*). 2
*Texas Painted Bunting (*Passerina ciris pallidior*). 4
*Dickcissel (*Spiza americana*). 4
*Arkansas Goldfinch (*Spinus psaltria psaltria*). 4

Migrants

Species that pass through the county in spring or fall, or both, but do not nest or winter here, are placed in this list.

Canada Goose (*Branta canadensis*). 2
White-fronted Goose (*Anser albifrons albifrons*). 1

Swainson Hawk (*Buteo swainsoni*). 3
Upland Plover (*Bartramia longicauda*). 1
*Solitary Sandpiper (*Tringa solitaria cinnamomea*). 3
Lesser Yellow Legs (*Totanus flavipes*). 3
Western Burrowing Owl (*Speotyto cunicularia hypogaea*). 2
Chimney Swift (*Chaetura pelagica*). 1
*Arkansas Kingbird (*Tyrannus verticalis*). 3
*Blue-headed Vireo (*Lanivireo solitarius solitarius*). 1
*Eastern Yellow Warbler (*Dendroica aestiva aestiva*). 3
Black-throated Green Warbler (*Dendroica virens virens*). 1
Maryland Yellow-throat (*Geothlypis trichas trichas*). 2
*Louisiana Water Thrush (*Seiurus motacilla*). 2
Canada Warbler (*Wilsonia canadensis*). 1
Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*). 2
*Thick-billed Red-wing (*Agelaius phoeniceus fortis*). 2
Lark Bunting (*Calamospiza melanocorys*). 2
*Nevada Savannah Sparrow (*Passerculus sandwichensis nevadensis*). 2
*Clay-colored Sparrow (*Spizella pallida*). 2
*White-crowned Sparrow (*Zonotrichia leucophrys leucophrys*). 3

Vagrants

Birds for which there are no records since 1919 are placed in this category. Recent accidentals are also included here. Undoubtedly many of these birds, especially the migrants, still occur in the county at the present time. The letter "a" indicates birds of accidental occurrence.

White Pelican (*Pelecanus erythrorhynchos*). 1-a
Mexican Cormorant (*Phalacrocorax olivaceus mexicanus*). 1-a
Water Turkey (*Anhinga anhinga*). 1
Black-crowned Night Heron (*Nycticorax nycticorax hoactli*). 1
*American Bittern (*Botaurus lentiginosus*). 1
Wood Ibis (*Mycteria americana*). 2
Black-bellied Tree Duck (*Dendrocygna autumnalis autumnalis*). 1-a
Shoveller (*Spatula clypeata*). 1
Wood Duck (*Aix sponsa*). 3
Buffle-head (*Charitonetta albeola*). 1
Ruddy Duck (*Erismatura jamaicensis rubida*). 1
American Merganser (*Mergus merganser americanus*). 2
Red-breasted Merganser (*Mergus serrator*). 1
Mississippi Kite (*Ictinia misisippiensis*). 1-a
Bald Eagle (*Haliaeetus leucocephalus* ssp.). 1
Zone-tailed Hawk (*Buteo albonotatus*). 3
Osprey (*Pandion haliaetus carolinensis*). 1
Audubon Caracara (*Polyborus cheriway auduboni*). 1
Pigeon Hawk (*Tinnunculus columbarius* ssp.). 3
Lesser Prairie Chicken (*Tympanuchus pallidicinctus*). 1
Arizona Scaled Quail (*Callipela squamata pallida*). 2
Sandhill Crane (*Grus canadensis tabida*). 4
Virginia Rail (*Rallus limicola limicola*). 1
Sora (*Porzana carolina*). 1-a
Purple Gallinule (*Porphyrula martinica*). 1
Florida Gallinule (*Gallinula chloropus cachinnans*). 1
American Golden Plover (*Pluvialis dominica dominica*). 1
Long-billed Curlew (*Numenius americanus americanus*). 3
*White-rumped Sandpiper (*Pisobia fuscicollis*). 3
*Baird Sandpiper (*Pisobia bairdi*). 1
Least Sandpiper (*Pisobia minutilla*). 2
*Semipalmated Sandpiper (*Ereunetes pusillus*). 2
Red-backed Sandpiper (*Pelidna alpina sakhalina*). 1-a
Avocet (*Recurvirostra americana*). 2

Black-necked Stilt (*Himantopus mexicanus*). 1
Franklin Gull (*Larus pipixcan*). 1-a
Black Tern (*Chlidonias nigra surinamensis*). 1
*Eastern White-winged Dove (*Melopelia asiatica asiatica*). 1
*Long-eared Owl (*Asio wilsonianus*). 1
Southern Pileated Woodpecker (*Ceophloeus pileatus pileatus*). 1-a
Williamson Sapsucker (*Sphyrapicus thyroideus thyroideus*). 1
Ant-eating Woodpecker (*Balanosphyra formicivora formicivora*). 4
*Eastern Kingbird (*Tyrannus tyrannus tyrannus*). 2
Couch Kingbird (*Tyrannus melancholicus couchi*). 1
*Mountain Flycatcher (*Empidonax traillii adastus*). 1
*Least Flycatcher (*Empidonax minimus*). 3
Olive-sided Flycatcher (*Nuttallornis borealis cooperi*). 1
Horned Lark (*Otocoris alpestris* ssp.). 1
Northern Blue Jay (*Cyanocitta cristata cristata*). 1
White-necked Raven (*Corvus cryptoleucus*). 1-a
Arizona Verdin (*Auriparus flaviceps flaviceps*). 1
*Baird Wren (*Thyromanes bewicki eremophilus*). 1
*Prairie Marsh Wren (*Telmatodytes palustris iliacus*). 3
*Catbird (*Dumetella carolinensis*). 1
Western Robin (*Turdus migratorius propinquus*). 1
*Alaska Hermit Thrush (*Hylocichla guttata guttata*). 2
*Mono Hermit Thrush (*Hylocichla guttata polionata*). 2
*Eastern Hermit Thrush (*Hylocichla guttata faxoni*). 2
*Olive-backed Thrush (*Hylocichla ustulata swainsoni*). 1
*Mountain Bluebird (*Sialia currucoides*). 3
*Townsend Solitaire (*Myadestes townsendi*). 3
*Rio Grande Vireo (*Vireo griseus micrus*). 2
*Nashville Warbler (*Vermivora ruficapilla ruficapilla*). 3
*Audubon Warbler (*Dendroica auduboni memorabilis*). 1
*Grinnell Water-thrush (*Seiurus noveboracensis notabilis*). 1
*Macgillivray Warbler (*Oporornis tolmiei*). 1
Northern Pileolated Warbler (*Wilsonia pusilla pileolata*). 1
American Redstart (*Setophaga ruticilla ruticilla*). 1
Baltimore Oriole (*Icterus galbula*). 1
*Nevada Cowbird (*Molothrus ater artemisiae*). 1
Black-headed Grosbeak (*Hedymeles melanocephalus melanocephalus*). 1
Rose-breasted Grosbeak (*Hedymeles ludovicianus*). 1
Lazuli Bunting (*Passerina amoena*). 2
Mexican Evening Grosbeak (*Hesperiphona vespertina montana*). 1
*Red-eyed Towhee (*Pipilo erythrophthalmus erythrophthalmus*). 1-a
*Arctic Towhee (*Pipilo maculatus articus*). 3
*Western Grasshopper Sparrow (*Ammodramus savannarum perpallidus*). 3
*Eastern Vesper Sparrow (*Pooecetes gramineus gramineus*). 2
Cassin Sparrow (*Aimophila cassini*). 2
Black-throated Sparrow (*Amphispiza bilineata bilineata*). 2
White-throated Sparrow (*Zonotrichia albicollis*). 1
*Dakota Song Sparrow (*Melospiza melodia juddi*). 3

A total of 248 kinds of birds has been recorded for Kerr County, 48 of which are permanent residents, 55 winter residents, 42 summer residents, 21 migrants, and 82 vagrants. The large number of vagrants is perhaps a result of the lack of adequate records during recent years. In all probability some of the birds listed in this category, such as the Wood Duck, Scaled Quail, and Prairie Marsh Wren, have been definitely eliminated from the county. Others, including the Eastern Hermit Thrush, Western Grasshopper Sparrow, and the Cassin Sparrow, probably occur there at the present time.

Except for the Longbilled Curlew, many of the migrants listed as vagrant, especially the sandpipers, undoubtedly still pass through either in spring or fall migrations.

As suggested by Dr. W. B. Davis ("Birds of Brazos County, Texas", Condor, vol. 42, pp. 81-85, 1940), the eastern edge (or

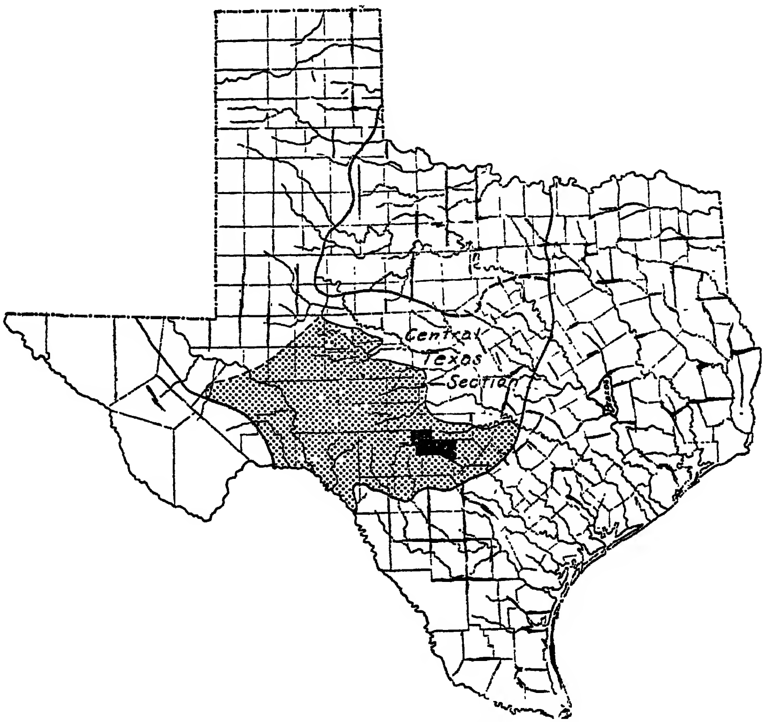


FIG. 1.—Map of Texas showing location of Kerr County (solid black), Brazos County (outlined in black), the Edwards Plateau (stippled), and the Central Texas Section. (Adapted from N. M. Fenneman, Physiography of the Western United States, 1931).

Balcones Escarpment) of the "first plateau" marks the eastern limit of most western birds occurring at this latitude in Texas. The first plateau to which he refers consists mainly of the Edwards Plateau, a young plateau with a mature margin, and the Central Texas Section, which is a mature plateau in later stages of erosion. Dr. Davis' assertion is upheld by the following table in which the breeding birds are compared as to geographical distribution. Under western birds in Table 1 are included those ranging throughout the Great Plains of the United States and Canada and west; southwestern birds include those ranging from central Texas, New Mexico, and Arizona to northern Mexico. Those species that occur east of the Great Plains

and east of the Balcones Escarpment in Texas are designated as eastern. In addition to the breeding birds, 10 western birds and four

TABLE 1.
The Breeding Birds Classified on the Basis of Geographical Range.

Western Birds	*Southwestern Birds*	*Eastern Birds*
Western Turkey Vulture	Fuertes Red-tailed Hawk*	Eastern Green Heron
Western Mourning Dove	Texas Bobwhite Quail	Cooper Hawk
Nuttall Poor-will*	Rio Grande Turkey*	Great Horned Owl*
Western Nighthawk*	Inca Dove*	Texas Barred Owl*
Black-chinned Hummingbird	Road-runner	Eastern Belted Kingfisher
Ash-throated Flycatcher*	Hasbrouck Screech Owl	Eastern Phoebe
Western Wood Pewee*	Cherrie Nighthawk	Eastern Wood Pewee
Canyon Wren*	Texas Green Kingfisher*	Southern Crow*
Common Rock Wren*	Texas Woodpecker*	Plumbeous Chickadee*
Western Mockingbird*	Vermilion Flycatcher*	Tufted Titmouse*
Bell Vireo	Lesser Cliff Swallow*	White-breasted Nuthatch
Western Parula Warbler	Texas Jay*	Carolina Wren*
Sonora Yellow Warbler	Lead-colored Bush-tit*	Eastern Bluebird
Long-tailed Chat*	Texas Wren*	Louisiana Cowbird
Bullock Oriole*	Sennett Titmouse	Indigo Bunting
Western Blue Grosbeak*	Black-capped Vireo	Eastern Field Sparrow
House Finch*	Golden-cheeked Warbler	
Western Lark Sparrow	Rio Grande Red-wing	
Western Chipping Sparrow*	Gray-tailed Cardinal*	
	Texas Painted Bunting	
	Arkansas Goldfinch	

*Species that find their range limits in the vicinity of Kerr County.

eastern birds frequent the county in winter. Fully 31 of the breeding birds known in the county find their range limit on the Edwards Plateau, this being 56 per cent of the total number of breeding species. Of the western and southwestern birds, 64 per cent are at their eastern limit here. The abrupt change from western to eastern species is perhaps caused in part by the substantial variations in climate between the plateau and the lower elevations to the east. The climate in Kerr County is significantly more xeric than that of Brazos County which is typical of the east Texas lowlands. Evaporation on the plateau is not only greater, but it also constantly exceeds the amount of precipitation. In addition to the dry climate, the thin rocky soils and heavy livestock grazing are important in determining the bird life of the plateau. In response to these factors, the breeding bird life of Kerr County contains more than twice as many western and southwestern forms as eastern.

As compared with the 40 birds migrating through Brazos County in spring and fall, without breeding or wintering, only 21 pass through Kerr County. The most obvious difference is in the large number of ducks that winter on the Edwards Plateau rather than continue migration further south. Occasional individuals of nine of the 11 species of ducks found as migrants in east Texas spend the winter on the streams of Kerr County. In addition eight warblers (mostly eastern forms) pass through Brazos County, but only two migrate through central Texas, both of these being typically eastern species.

Note on the Occurrence of some Eastern Wisconsin Plants

CHARLES G. SCHOEWE
Milwaukee, Wisconsin

Trilliums grow in the woodlands of eastern Wisconsin in great numbers. In the later part of June, 1945, however, I found in the woods at Moose Lake, Waukesha County, about 25 miles west of Milwaukee, Wisconsin, a specimen of the rare double-flowering form of *Trillium grandiflorum*. This specimen resembles a double white carnation more than the common trillium. The leaves are like those of the common trillium except that they are very much larger and have a decided white streak running through the center of some of the leaves. According to Albert Fuller, curator of botany at the Milwaukee Public Museum who examined the specimen, this doubled type of trillium is very rare in eastern Wisconsin. Thus far he has seen only two specimens among the thousands of trilliums he has examined.

In the early part of August, 1945, I also found in the same general locality a cluster of 8 or 9 specimens of a white or albino variety of the wild Bergamot *Monarda fistulosa*. The common Bergamot in this part of the country, where it grows in profusion, is magenta-purple. Close by was also a fine growth of ginseng (*Panax quinquefolium*) which at the time of my visit in August was in the green berry stage.

Annual Report of the Treasurer

KANSAS ACADEMY OF SCIENCE

April 11, 1945 to April 6, 1946

Receipts

Balance in checking account, April 11, 1945		$ 313.70
Annual dues for memberships		975.00
Four life members		82.00
Sale of *Transactions*		106.80
Sale of *Winter Twigs*		21.81
Reprints		409.63
State of Kansas		600.00
Exchange Rights		500.00
AAAS (1944 and 1945)		134.50
Endowment Fund		1.00
Interest on Investments		75.52
U. S. Treasury Bonds (called in—1945)		850.00
Total		$4,069.96

Disbursements

Secretary—stationery, help, express charges, stamps, etc.		$ 188.02
Treasurer—lock box, report, bonds		23.75
President—stamps and envelopes		19.34
Editorial Board		
Managing Editor—membership cards, envelopes, etc.		34.03
Vol. 47-2 Engraving	$ 9.74	
Vol. 48-1 Engraving	104.42	
Vol. 48-2 Engraving	44.93	
Vol. 48-3 Engraving	27.75	
Vol. 48-4 Engraving	12.27	199.11
Editor		
Vol. 47-2 Printing	$600.20	
Vol. 47-3 Printing	595.60	
Vol. 48-1 Printing	517.30	
Vol. 48-2 Printing	445.35	
Vol. 48-3 Printing	463.95	
Printing extra tables, covers	23.50	$2,645.90
Sectional Chairmen		
Zoology Section		1.17
Geology Section		3.25
		$3,114.57
Balance in checking account, April 6, 1946		955.39
Total		$4,069.96

Supplementary Statement

Accounts Receivable (Reprints)	$ 91.42
Accounts Payable (Spring programs)	39.00
Endowment Fund	4,100.00
Interest on Endowment Fund	336.59

Awards Account

Amount in fund, 4/10/45		120.90
Received during year—AAAS	$ 70.00	
Reagan	25.00	95.00
Total		$ 215.90
Awarded	$150.00	
Amount paid	.00	
Balance		$ 215.90

F. W. ALBERTSON, *Treasurer.*

Transactions
Kansas Academy of Science

Volume 49, No. 4 | March, 1947

Kansas Weather: 1946

S. D. FLORA
U. S. Weather Bureau, Topeka.

Some bitter critic of mankind once wrote "A change of weather is the discourse of fools." If the critic be right then most of us are fools, for weather is of never-failing interest and an ever ready subject of discourse for one and all. So imperfect are our memories that the review of Kansas weather for the past year which follows will doubtless refresh recollections of events just past as well as furnish a written and reliable record of Kansas climate during 1946 for future historians.

The author of this review needs no introduction to a Kansas audience because a service of over forty years in the United States Weather Bureau at Topeka has made the name of Meteorologist Flora one of the best known in the state.—The Editor.

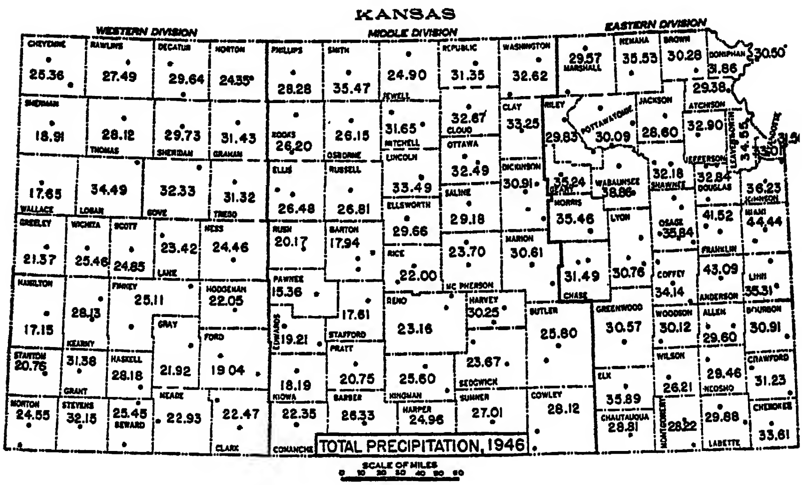
General Review

The weather of Kansas during 1946 was generally of the pleasant variety and favorable for practically all crops except corn. The opening months, when severely cold weather ordinarily occurs, were exceptionally mild, the summer generally comfortable, and the fall and early winter months were fine.

Precipitation was sufficient over most of the eastern two-thirds and abnormally heavy over the western third, where it averaged the greatest on record, except for the years of 1915, 1923, and 1941. The average for the eastern third was 33.47 inches; the middle third, 26.15 inches; the western third, 25.29 inches; and for the state as a whole, 28.29 inches, which was 1.32 inches above normal and 1.91 less than in 1945. The greatest total reported was 44.44 inches at Paola and the least, 15.36 inches, at Larned. A large number of western counties reported from 25 to 30 inches, or more. Snowfall of the year was the third smallest on the state's record, though exceptionally heavy snows fell in the western counties in November.

The year as a whole averaged one of the warmest on record with a mean of 57.8°, which was 2.8° above normal. The highest reading reported was 114° on August 7 at Ellsworth, Lincoln, Medicine

Lodge, and near Bison. The lowest was 12° below zero on December 30 near Burr Oak, Jewell County. The first four months averaged the mildest on record for this time of year and at the end of April all crops were three to four weeks ahead of the season. Planting corn was more than half completed. In some southern counties a few commercial fields of potatoes were planted in February. By the end



of April, wheat was generally in the boot and some fields had headed out in southern counties. May was cold and wet, with a rather severe freeze on the 11th in all parts of the state except the eastern and extreme south-central counties. Wheat, however escaped serious damage, though it was either heading or ready to head.

June, July, and the fore part of August were abnormally warm and in many parts of the state precipitation was deficient. Generous rains fell in some of the north-central counties in July and over most of the northeastern quarter the second week of August, but elsewhere corn was practically ruined and pastures poor. Sufficient rainfall and warm weather in September and October revived pastures and was fine for the new wheat crop. November and most of December were mild and with plenty of moisture, which resulted in an unusually good start for wheat. Over the western third the precipitation of November was a record-breaker and left the soil more thoroughly soaked. Heavy snows the fore part of this month in the same area caused some loss of sheep and poultry and made wheat fields too wet to pasture for a few weeks.

Windstorms

Only 11 tornadoes were reported during the year, which is the least number in any year since 1931. One person was killed. Estimates of property damage totalled $312,500, which is scarcely half the annual average.

The most damaging tornado of the year and the only one that resulted in loss of life occurred in Washington County on May 23, which followed a path 20 miles long from near Washington to northeast of Hanover. Thirty families were affected, 16 residences, and 60 other buildings were destroyed or damaged. Loss from this storm was placed at $131,500.

The number of violent windstorms not of tornadic nature that was reported was 25, with estimated property damage totalling $632,500, which was less than a fourth of that of the year previous. The most destructive of these occurred in connection with a hailstorm in Anderson County on the night of August 12-13. There seemed to be three separate storms that occurred over the same path, from Harris to near Bush City. From 30 to 40 barns and outbuildings were demolished or badly damaged and considerable damage occurred in City Park, Garnett.

Hail

A total of 46 heavy or severe occurrences of hail was reported, with estimated damages totalling $3,716,500, as contrasted with 85 such storms causing damage estimated at $10,698,500 during the year previous. Hail was more frequent in May than in any other month but individual storms that caused the most damage occurred in June and July.

The greatest damage from a single hailstorm during the year occurred July 2 in the northwestern part of Cheyenne County. Wheat was struck just before harvest and it and other crops in the storm path were practically wiped out and some livestock killed. Damage was placed at $1,250,000. Another especially destructive hailstorm occurred in Cloud, Jewell, Mitchell, Republic, and Ottawa Counties on June 14. This storm was especially severe near Jamestown, where damage to wheat ranged up to 100 per cent. Hailstones as large as baseballs fell during this storm. Damage from hail was estimated at $775,000, with an additional damage of $100,000 from high winds that accompanied the storm.

Overflows

Overflows were spread over eight months of the year and occurred in practically every river, except the Kansas. Most of them

were slight or moderate and in several instances only small sections of the rivers flooded. Serious overflows that were among the greatest on record occurred along the lower Blue; along the Republican in Franklin, Webster, and Nuckolls Counties, Nebraska; along the Solomon and Saline Rivers; and in tributary creeks of the Marais des Cygnes (Osage) above Quenemo.

Total damage of all overflows, as obtained from preliminary estimates, was $923,967, with $336,000 additional along the Republican in Nebraska.

The Solomon River overflowed eight times at Beloit but only three times from that point to its mouth. The most serious of these floods crested on September 8 with a stage of 29.28 feet, 11.28 feet above bankful, at Beloit; 31.88 feet, 5.88 feet above bankful, at Minneapolis; and 30.12 feet, 6.12 feet above bankful, at Niles. There was also extensive damage along the North Fork of the Solomon in August. Losses in this watershed were estimated at $174,867.

Overflows in parts of the Republican River occurred in July, September, and October, but none were serious except the latter, which reached the highest crests since 1935 at Bloomington and Guide Rock, Nebraska. This overflow was accompanied by rather serious overflows in Beaver, Sappa, and Prairie Dog Creeks. Total damage was estimated at $386,000, of which only $50,000 was in Kansas.

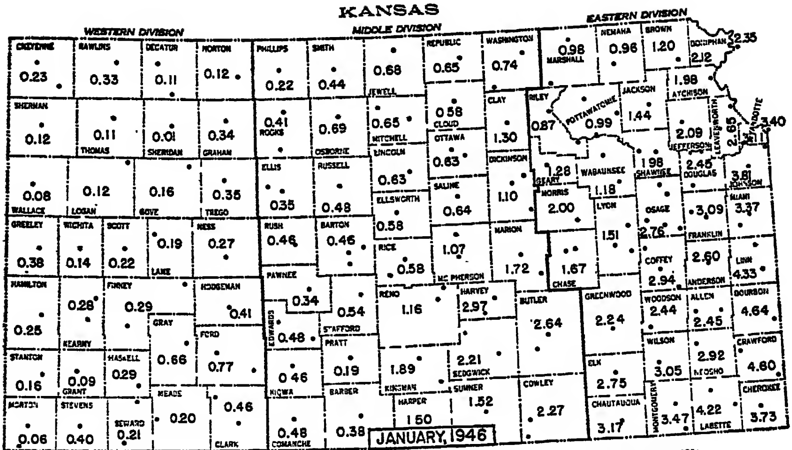
Both the Big and Little Blue Rivers overflowed in July and this overflow was rather serious at Blue Rapids and Randolph, where crests of 29.25 feet and 24.6 feet, respectively, were reported. Damage from these overflows was estimated at $24,000.

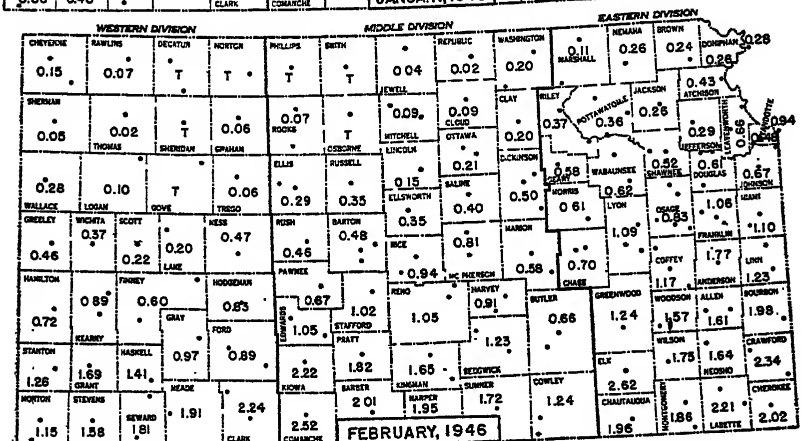
The Smoky Hill overflowed slightly from Abilene to its mouth in September and at Abilene in October. Damage was estimated at $57,000.

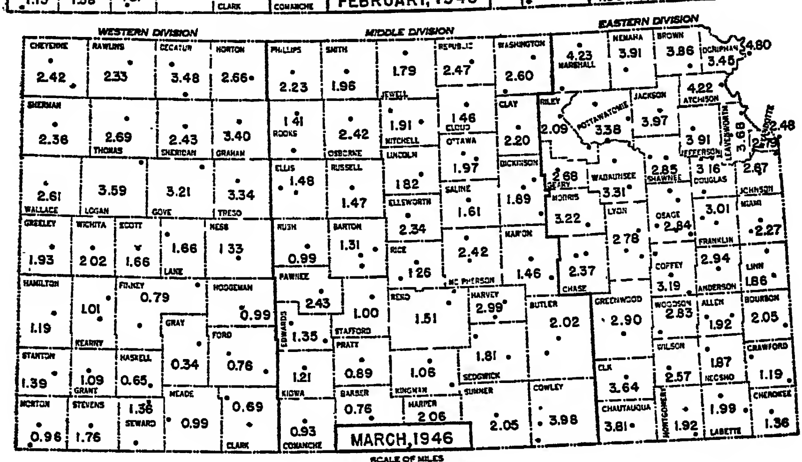
The Saline staged two rather serious overflows in September and October, reaching a near-record crest of 29.07 feet, 4.07 feet above bankful, at Tescott on October 9. Damage in this basin was estimated at $115,000.

The Marais des Cygnes (Osage) overflowed at some points in April, May, June, and August. None of these overflows were serious, except in some small tributaries above Quenemo in June. Estimated damage in this basin totalled $117,600.

A slight overflow occurred in the Neosho at Oswego in January


KANSAS
WESTERN DIVISION
MIDDLE DIVISION
EASTERN DIVISION
JANUARY, 1946


WESTERN DIVISION
MIDDLE DIVISION
EASTERN DIVISION
FEBRUARY, 1946


WESTERN DIVISION
MIDDLE DIVISION
EASTERN DIVISION
MARCH, 1946
SCALE OF MILES

and a moderate overflow along the Cottonwood and Neosho to Iola in June. Estimated damage was $297,000.

A slight overflow occurred in the Arkansas at Great Bend in October, with little or no damage.

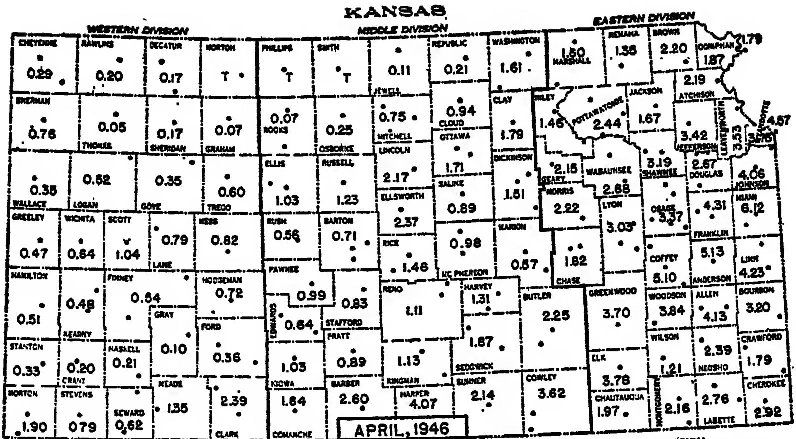
Monthly Summaries

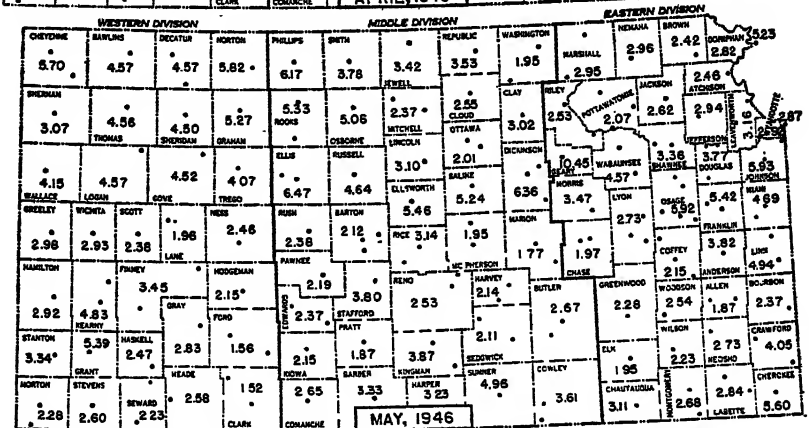
January.—This month was exceptionally wet over nearly all the eastern part of Kansas and exceptionally dry in the western counties. It was one of the mildest Januarys on the state's record and averaged 7° milder than December preceding. Snowfall was unusually light for the time of year and melted rapidly, leaving the ground bare most of the month. In the eastern counties, muddy fields and feed lots and unsurfaced roads that were almost impassable at times hampered farm work materially. Wheat greened up somewhat in the eastern part but its top growth was less than usual at this time of the year.

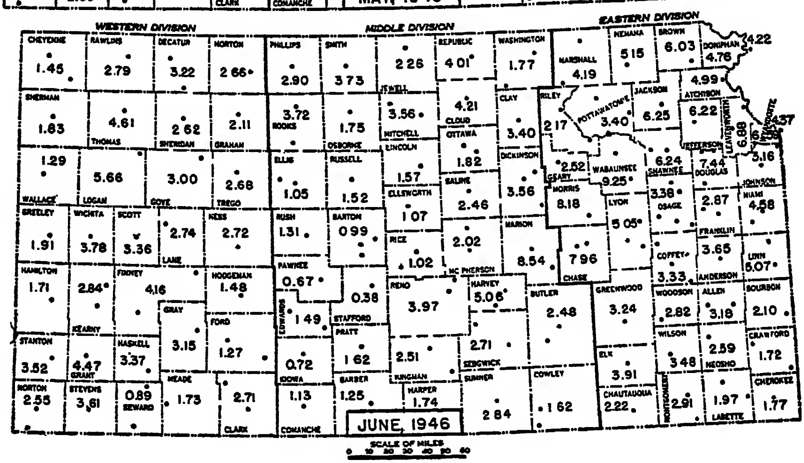
February.—This also was an exceptionally mild sunshiny month for the time of year and over the northern part of the state was exceptionally dry. It completed a five-month period which, in the western two-thirds of the state, averaged the driest that has occurred at this time of the year since the winter of 1934-35. Dust storms or blowing dust, which were severe in some localities, were reported from the northwestern counties on several days. It was a favorable month for farm work. Seeding oats was more than half completed in the south-central and southeastern counties and was well under way elsewhere. Some early gardens were made and, in the Kaw Valley, a few commercial fields of potatoes were planted. Wheat greened up in the eastern and southwestern counties but continued in a precarious condition in the northwestern quarter of the state.

March.—Exceptionally mild weather, with generally abundant rains and ample sunshine, made this a very favorable month for crop growth over the state. Vegetation, especially fruit, was forced almost a month in advance of the season, with a serious probability of damage by freezing before spring had passed. Wheat made a fine start and was beginning to joint in some fields at the close. In some localities the growth was considered to be too rank for the time of year.

April.—This month came very nearly being a record-breaker for continued mild weather, with decidedly deficient rainfall practically all over the state, except the eastern counties. It completed a four-month period that averaged the mildest ever recorded in the state during this part of the year. All crops were from three to four


KANSAS
WESTERN DIVISION
MIDDLE DIVISION
EASTERN DIVISION
APRIL, 1946


WESTERN DIVISION
MIDDLE DIVISION
EASTERN DIVISION
MAY, 1946


WESTERN DIVISION
MIDDLE DIVISION
EASTERN DIVISION
JUNE, 1946
SCALE OF MILES
0 10 20 30 40 50 60

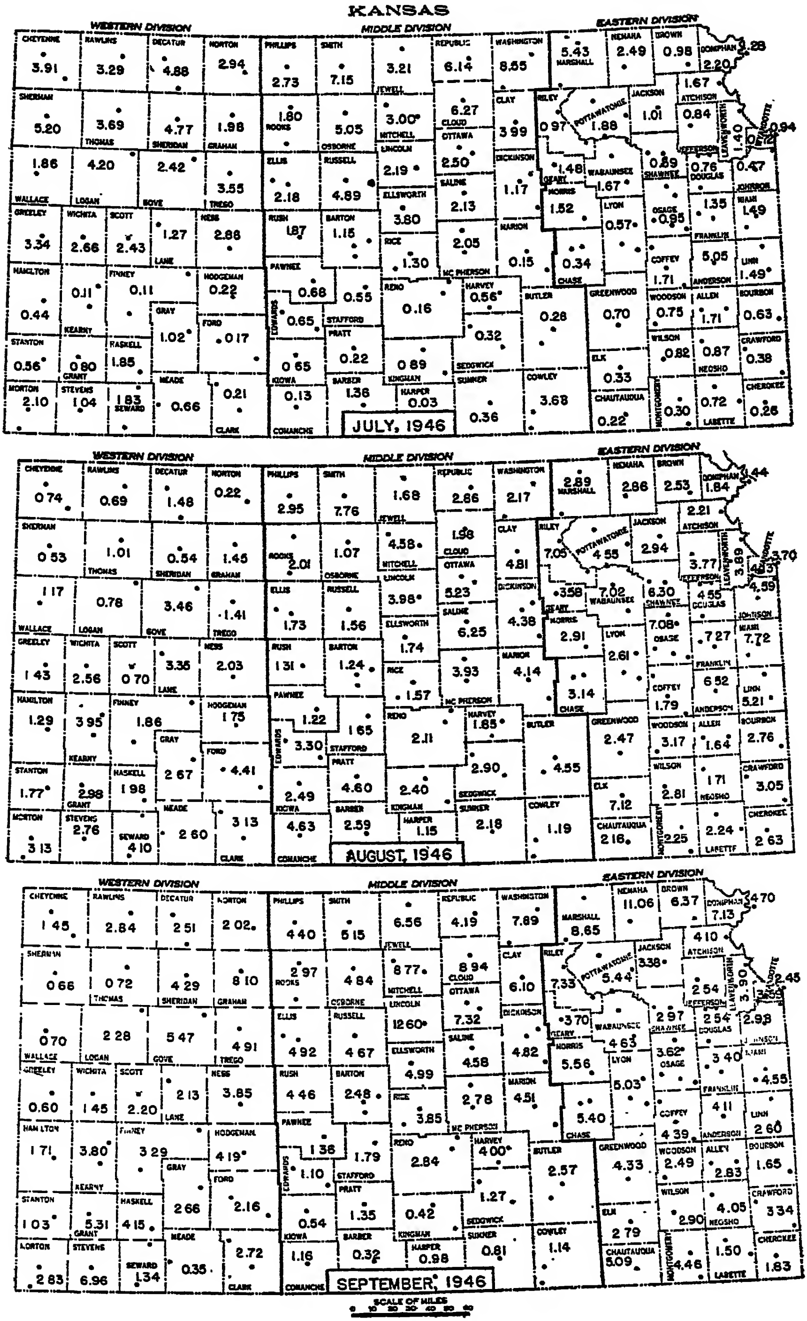
weeks ahead of the season. Wheat was in the boot by the close of the month, with many fields of early varieties heading out in the southern counties. The crop was needing moisture rather badly the last week and was deteriorating steadily in the southwestern and west-central areas.

May.—This month gave western Kansas more rain than it had received in any other month in almost two years, but there were many dry spots in the eastern counties when it closed. It was an abnormally cool month, with a damaging freeze over the western half on the 11th. With the exception of this freeze, it was a favorable month for wheat, though the development of the crop was slow. Corn made a good, but rather slow growth and most of it had been cultivated when the month ended. The first cutting of alfalfa was generally secured.

June.—This was the warmest June experienced in Kansas in ten years. Rainfall was below normal over most of the western two-thirds of the state and the southeastern counties but many of the eastern counties had torrential downpours. Hot dry weather near the middle of the month was trying on growing crops and vegetation, but wheat ripened fast and generally filled satisfactorily. Harvest began earlier than usual. Corn made an excellent growth after rains began on the 18th.

July.—This was the hottest and driest July Kansas had experienced in six years, with considerably less sunshine than usual. Rainfall was very unevenly distributed over the state. Generous amounts were reported over most of the north-central and northwestern counties, while the southern half and a number of northeastern counties were in the grip of a severe drought. The hot dry weather caught corn at a critical period of its growth, while it was silking and tasseling, and the crop deteriorated steadily during the latter part of the month, especially in the southern and eastern counties. Pastures and alfalfa made little growth.

August.—Torrential rains of local nature broke a severe drought over most of the northeastern quarter of the state in the second week of this month, but many southern and western counties remained dry. The first 17 days of the month were abnormally hot, while the closing week was exceptionally cool. Corn was badly damaged by hot weather the fore part of the month, especially in the southern and western counties. Grain sorghums were also seriously damaged.


KANSAS
WESTERN DIVISION
MIDDLE DIVISION
EASTERN DIVISION
JULY, 1946
AUGUST, 1946
SEPTEMBER, 1946
SCALE OF MILES

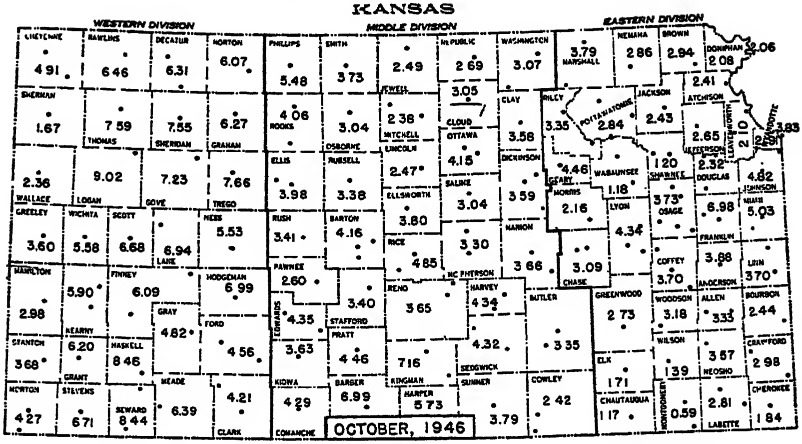
September.—Generous rains over most of the state, with much warm weather, made this a favorable month for crop growth and fall seeding. There were dry areas in the north-central counties and the extreme western end of the state that received less than an inch. Most of the month's rain fell in heavy local downpours, with overflows of rivers resulting in the north-central portion. Corn matured satisfactorily and was practically all safe from frost by the close. Sowing wheat began early in the month in the western counties and was practically completed there, with the crop coming up to excellent stands.

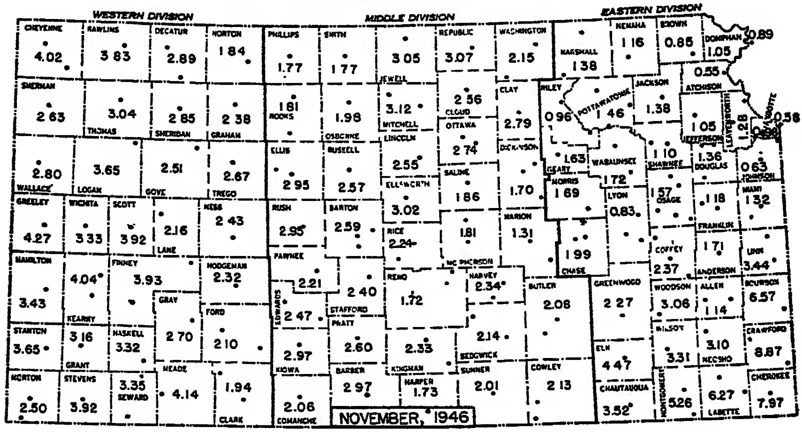
October.—More rain fell this month than in any other month in a year's time, making it the third wettest October on the state's record. Over the western third, where totals of five to seven inches were common, it was, without exception, the wettest October on record. The only parts of the state that remained persistently dry were the southeastern counties. Temperatures averaged considerably above normal over the eastern third but in the western third the average was below normal. It was a fine month for the early fall growth of wheat. Volunteer wheat in the western counties made a rank growth and furnished excellent pasture.

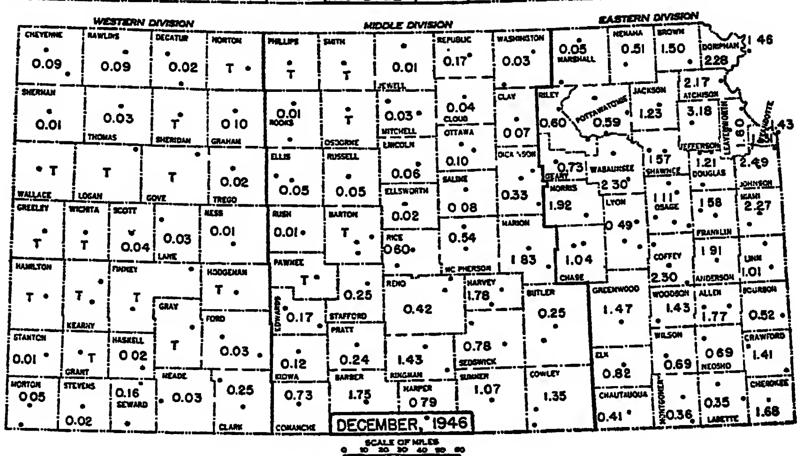
November.—Unusually heavy snow in the western part of the state and generous rains in almost all sections characterized this month. The western third received more precipitation than had been recorded in any other November in 60 years, except one. The soil was thoroughly soaked in all parts of the state. Temperatures averaged near normal. There were no especially cold or warm spells. It was a favorable month for wheat, which, as a rule, covered the ground and had sufficient moisture in the soil to carry it through the winter. Farm work was hampered by muddy fields the fore part of the month. The heavy snows in the western counties resulted in some losses of sheep and poultry.

December.—Milder weather prevailed this month than in any other December in seven years. The amount of precipitation was deficient in all parts but an abundance of soil moisture had been carried over from the previous month. It was a favorable month for wheat, for which there was an abundant supply of moisture in all parts of the state. Drying out of the top soil made it possible to take advantage of the excellent pasture the wheat furnished and livestock went into winter in good condition.

KANSAS


WESTERN DIVISION
MIDDLE DIVISION
EASTERN DIVISION
CHEYENNE 4.91
RAWLINS 6.46
DECATUR 6.31
NORTON 6.07
PHILLIPS 5.48
SMITH 3.73
JEWELL 2.49
REPUBLIC 2.69
WASHINGTON 3.07
MARSHALL 3.79
NEMAHA 2.86
BROWN 2.94
DONIPHAN 2.08
2.06
SHERMAN 1.67
THOMAS 7.59
SHERIDAN 7.55
GRAHAM 6.27
ROOKS 4.06
OSBORNE 3.04
MITCHELL 2.38
CLOUD 3.05
CLAY 3.58
RILEY 3.35
POTTAWATOMIE 2.84
JACKSON 2.43
ATCHISON 2.41
LEAVENWORTH 2.10
WYANDOTTE 2.51
3.83
JEFFERSON 2.65
2.36
WALLACE
LOGAN 9.02
GOVE 7.23
TREGO 7.66
ELLIS 3.98
RUSSELL 3.38
LINCOLN 2.47
OTTAWA 4.15
DICKINSON 3.59
GEARY 4.46
WABAUNSEE 1.18
SHAWNEE 1.20
DOUGLAS 2.32
JOHNSON 4.82
GREELEY 3.60
WICHITA 5.58
SCOTT 6.68
LANE 6.94
NESS 5.53
RUSH 3.41
BARTON 4.16
ELLSWORTH 3.80
SALINE 3.04
MORRIS 2.16
LYON 4.34
OSAGE 3.73
FRANKLIN 6.98
MIAMI 5.03
HAMILTON 2.98
KEARNY 5.90
FINNEY 6.09
GRAY 4.82
HODGEMAN 6.99
PAWNEE 2.60
EDWARDS 4.35
STAFFORD 3.40
RICE 4.85
MC PHERSON 3.30
MARION 3.66
CHASE 3.09
COFFEY 3.70
ANDERSON 3.88
LINN 3.70
STANTON 3.68
GRANT 6.20
HASKELL 8.46
FORD 4.56
KIOWA 3.63
PRATT 4.46
RENO 3.65
HARVEY 4.34
BUTLER 3.35
GREENWOOD 2.73
WOODSON 3.18
ALLEN 3.33
BOURBON 2.44
SEDGWICK 4.32
KINGMAN 7.16
ELK 1.71
WILSON 1.39
NEOSHO 3.57
CRAWFORD 2.98
MORTON 4.27
STEVENS 6.71
SEWARD 8.44
MEADE 6.39
CLARK 4.21
COMANCHE 4.29
BARBER 6.99
HARPER 5.73
SUMNER 3.79
COWLEY 2.42
CHAUTAUQUA 1.17
MONTGOMERY 0.59
LABETTE 2.81
CHEROKEE 1.84
OCTOBER, 1946


WESTERN DIVISION
MIDDLE DIVISION
EASTERN DIVISION
CHEYENNE 4.02
RAWLINS 3.83
DECATUR 2.89
NORTON 1.84
PHILLIPS 1.77
SMITH 1.77
JEWELL 3.05
REPUBLIC 3.07
WASHINGTON 2.15
MARSHALL 1.38
NEMAHA 1.16
BROWN 0.86
DONIPHAN 1.05
0.89
SHERMAN 2.63
THOMAS 3.04
SHERIDAN 2.85
GRAHAM 2.38
ROOKS 1.81
OSBORNE 1.98
MITCHELL 3.12
CLOUD 2.56
CLAY 2.79
RILEY 0.96
POTTAWATOMIE 1.46
JACKSON 1.38
ATCHISON 0.55
LEAVENWORTH 1.28
JEFFERSON 1.05
0.58
WALLACE 2.80
LOGAN 3.65
GOVE 2.51
TREGO 2.67
ELLIS 2.95
RUSSELL 2.57
LINCOLN 2.55
OTTAWA 2.74
DICKINSON 1.70
GEARY 1.63
WABAUNSEE 1.72
SHAWNEE 1.10
DOUGLAS 1.36
JOHNSON 0.63
GREELEY 4.27
WICHITA 3.33
SCOTT 3.92
LANE 2.16
NESS 2.43
RUSH 2.95
BARTON 2.59
ELLSWORTH 3.02
SALINE 1.86
MORRIS 1.69
LYON 0.83
OSAGE 1.57
FRANKLIN 1.18
MIAMI 1.32
HAMILTON 3.43
KEARNY 4.04
FINNEY 3.93
RICE 2.24
MC PHERSON 1.81
MARION 1.31
CHASE 1.99
COFFEY 2.37
ANDERSON 1.71
LINN 3.44
HODGEMAN 2.32
PAWNEE 2.21
EDWARDS 2.47
STAFFORD 2.40
RENO 1.72
HARVEY 2.34
BUTLER 2.08
GREENWOOD 2.27
WOODSON 3.06
ALLEN 1.14
BOURBON 6.57
STANTON 3.65
GRANT 3.16
HASKELL 3.32
GRAY 2.70
FORD 2.10
KIOWA 2.97
PRATT 2.60
KINGMAN 2.33
SEDGWICK 2.14
ELK 4.47
WILSON 3.31
NEOSHO 3.10
CRAWFORD 8.87
MORTON 2.50
STEVENS 3.92
SEWARD 3.35
MEADE 4.14
CLARK 1.94
COMANCHE 2.06
BARBER 2.97
HARPER 1.73
SUMNER 2.01
COWLEY 2.13
CHAUTAUQUA 3.52
MONTGOMERY 5.26
LABETTE 6.27
CHEROKEE 7.97
NOVEMBER, 1946


WESTERN DIVISION
MIDDLE DIVISION
EASTERN DIVISION
CHEYENNE 0.09
RAWLINS 0.09
DECATUR 0.02
NORTON T
PHILLIPS T
SMITH T
JEWELL 0.01
REPUBLIC 0.17
WASHINGTON 0.03
MARSHALL 0.05
NEMAHA 0.51
BROWN 1.50
DONIPHAN 2.28
1.46
SHERMAN 0.01
THOMAS 0.03
SHERIDAN T
GRAHAM 0.10
ROOKS 0.01
OSBORNE T
MITCHELL 0.03
CLOUD 0.04
CLAY 0.07
RILEY 0.60
POTTAWATOMIE 0.59
JACKSON 1.23
ATCHISON 2.17
3.18
LEAVENWORTH 1.60
WYANDOTTE 1.43
JEFFERSON
T
LOGAN T
GOVE T
TREGO 0.02
WALLACE
ELLIS 0.05
RUSSELL 0.05
LINCOLN 0.06
OTTAWA 0.10
DICKINSON 0.33
GEARY 0.73
WABAUNSEE 2.30
SHAWNEE 1.57
DOUGLAS 1.21
2.49
JOHNSON
GREELEY T
WICHITA T
SCOTT 0.04
LANE 0.03
NESS 0.01
RUSH 0.01
BARTON T
ELLSWORTH 0.02
SALINE 0.08
MORRIS 1.92
LYON 0.49
OSAGE 1.11
FRANKLIN 1.58
MIAMI 2.27
HAMILTON T
KEARNY T
FINNEY T
HODGEMAN T
PAWNEE T
RICE 0.60
MC PHERSON 0.54
MARION 1.83
CHASE 1.04
COFFEY 2.30
ANDERSON 1.91
LINN 1.01
GRAY T
EDWARDS 0.17
STAFFORD 0.25
RENO 0.42
HARVEY 1.78
BUTLER 0.25
GREENWOOD 1.47
WOODSON 1.43
ALLEN 1.77
BOURBON 0.52
STANTON 0.01
GRANT T
HASKELL 0.02
FORD 0.03
KIOWA 0.12
PRATT 0.24
KINGMAN 1.43
SEDGWICK 0.78
ELK 0.82
WILSON 0.69
NEOSHO 0.69
CRAWFORD 1.41
MORTON 0.05
STEVENS 0.02
SEWARD 0.16
MEADE 0.03
CLARK 0.25
COMANCHE 0.73
BARBER 1.75
HARPER 0.79
SUMNER 1.07
COWLEY 1.35
CHAUTAUQUA 0.41
MONTGOMERY 0.36
LABETTE 0.35
CHEROKEE 1.68
DECEMBER, 1946
SCALE OF MILES
0 10 20 30 40 50 60

The Climate of Kansas: 1859

The climate of Kansas somewhat differs from that of the States in the same latitude east of the Mississippi. It is generally regarded as exceedingly lovely. The air is dry, clear, pure, vitalizing. The summers and autumns are long, and the winters very short and mild; there are occasionally exceptions to this rule, for in the winter of 1855, the thermometer at Lawrence stood nearly for a week from 12 to 20 degrees below *zero. Whenever, however, it has been cold in Kansas, it has been much more inclement in the Eastern States. Snow seldom falls—never enough for sleighing; the greatest depth ever known, within living memory, was six inches only. Drouths are rare. We have known the thermometer to stand at 115 degrees; but notwithstanding this apparent excessive heat, in consequence of the cool breezes, it was not unendurable to recent Northern emigrants, nor even disagreeable to them. The nights are* always *cool. The seasons are some weeks earlier than in Ohio, New York, and New England; the weather more pleasant than that of Illinois, Iowa, or Nebraska. Fires are seldom needed till Christmas. February, March, and April are the most disagreeable months in the year. During this period the changes of temperature are unusually sudden, frequent, and severe. It is not uncommon for the thermometer to fall between thirty and forty degrees in the course of a forenoon, or sometimes in less than four hours. The winds, too, are fierce, and terribly bitter. Rains are frequent—the lightnings sublime. A thunder-storm in Kansas is the most magnificent of celestial phenomena. The whole heavens appear in a blaze. The rainy season extends from May 10 to June 10. The annual fall is under thirty inches—less than in the Eastern States. There is very little rain in midsummer or autumn. During the rainy period the roads and creeks are sometimes impassable for several days in succession.*

Take it for all in all, Kansas has the most pleasant climate of any Western State, Missouri alone—which equals, but not surpasses it—excepted.—From Redpath and Hinton, *Handbook to Kansas Territory,*1859.

The Editor's Page

Transactions
of the
Kansas Academy of Science
Published Quarterly
by the
KANSAS ACADEMY OF SCIENCE
(Founded 1868)
OFFICERS
Claude W. Hibbard, Lawrence, President.
F. C. Gates, Manhattan, Secretary.
S. V. Dalton, Hays, Treasurer.

VOL. 49, NO. 4 MARCH, 1947

ROBERT TAFT, *Editor*

As time advances with sure and certain steps upon the editor, he finds his former activities and pleasures undergoing change; probably not a novel discovery for any son of Adam. At least one pleasure lingers, however, and one that grows stronger as age advances, for the love of natural beauty still remains and grows greater in its intensity as the years pass. How often does a welcome—if momentary—respite from the cares of the day come as former scenes briefly flash across the mind, not only from childhood's fond recollection but from every decade of life. The lovely and beautiful Chenango hills and valleys of central New York, the Appalachians of West Virginia where early morning views far above the clouds in the valleys below gave an uplift that forty years have not diminished. And in later years the boundless lands of the Great Plains, the unbelievable views of those Plains from the Front Range of the Rockies, to say nothing of the enchanting pine and flower bordered lakes of the High Country. Eastern Kansas, too, has contributed its share of natural beauty. I can still recall a view one Sunday morning in autumn nearly twenty years ago; a view from the hilltop of a narrow country road a few miles from Lawrence where suddenly there opened a wide vista over a succession of brown and red and yellow valleys, softened by a bright and nebulous haze that left me scarcely believing that such a sight could exist in the land of living men. The purple mists that can be seen once in a long, long time from Mount Oread creeping eastward down the Wakarusa valley on an early winter evening, also bring occasions for quiet rejoicing. Even a writer of purplest hue could not find sufficiently florid adjectives to describe these rare occasions. In central Kansas, also, I have traveled northward on a summer evening rather frequently over state highway 14 as Mankato, near the Kansas-Nebraska border, is approached. As one leaves the valley below and rises to the topmost level of a great upthrust of land that lies a few miles south and east of Mankato, deep canyons appear to the left. Looking down those widening canyons, the view leads to the Great

Plains beyond. With clouds and sunset rightly joined, one again wonders if, by some great good fortune—not ordinarily vouchsafed to university professors and editors—the happy hunting grounds have not at last been safely reached.

With such an attitude of mind it should not be hard to understand why another pleasure has been added in recent years to the editor's limited range of satisfactions—that of reading the poets of the out-of-doors, poets whose work was required reading in school-boy days. I think I enjoyed their work then, but the satisfaction they now bring is doubled or trebled—or possibly more greatly multiplied as I have no reliable method of measuring satisfaction. Of these poems, Scott's *Lady of the Lake* brings me as much pleasure as any—an admission that will doubtless put me among the lowbrows by my colleagues in the English department; but as these well-meaning and polite individuals already look down their collective noses at odorous chemists, their opinion—possibly I should say their judgment—will not greatly disturb me. At any rate, many readings of *The Lady of the Lake* have brought a measure of relief on numerous sleepless nights.

The crippled Scott's veneration of natural beauty was nearly an obsession. In fact, in his brief autobiography he wrote ". . . the love of natural beauty . . . became an insatiable passion, which, if circumstances had permitted, I would willingly have gratified by traveling over half the globe." And in *The Lady of the Lake,* this love of natural beauty is apparent in nearly every line. To be sure, the meter of the lines and the perfection of many of its characters become monotonous at times, but by the skillful use of interludes, which at times surmount in feeling the body of the text itself, this monotony is successfully interrupted. My knowledge of literature gives me no such satisfying lines as can be found in the "Coronach," the heartfelt and melodious lament for the dead Duncan, which employs to the full, imagery borrowed from nature itself. Many—if there are many—of my readers must recall it.

He is gone on the mountain,
  He is lost to the forest,
Like a summer-dried fountain,
  When our need was the sorest.
The font, reappearing,
  From the rain-drops shall borrow,
But to us comes no cheering,
  To Duncan no morrow!

The hand of the reaper
  Takes the ears that are hoary,
But the voice of the weeper
  Wails manhood in glory.
The autumn winds rushing
  Waft the leaves that are searest,
But our flower was in flushing
  When blighting was nearest.

Fleet foot on the correi,
  Sage counsel in cumber,
Red hand in the foray,
  How sound is thy slumber!
Like the dew on the mountain,
  Like the foam on the river,
Like the bubble on the fountain
  Thou art gone, and forever!

What an editorial for a scientific journal! Well, we live in a topsy-turvy day when the preacher and the poet, with little knowledge, expound the mysteries of the atom, and a chemist, with less knowledge, attempts to describe some satisfactions of a curious soul.

* * *

Readers of the *Transactions* should be pleased to know that not all editorials will be so far afield as the one above. In fact,

the editorial on conservation in the last issue (December) may have done some good. The American Legion which is sponsoring a bill for a new state fish and game commission containing trained biologists among its members, sent a committee to Topeka to urge the passage of the bill and visited members of the Legislature and Governor Carlson. The editorial in our December issue was shown to those interested and Governor Carlson himself was said to have been "greatly impressed" with the editorial. Governor Carlson, however, being in his first term, is "greatly impressed" with many things. Possibly the editorial will aid in the passage of the new bill. The editor hopes that his pet project, however, a co-ordinated study of long range conservation in all its aspects in the state, soil, water, fish, game and scenic areas, will eventually be made. It can be put off too long.

"NOT PEACE BUT A SWORD"

Charity, respect for others, integrity, goodness, are not just shibboleths handed down by society to keep its individual members in order. They are essential virtues welling up from the spirit that make a free society possible. "Be noble" wrote Lowell "and the nobleness that lies in other men, sleeping but never dead, will rise in majesty to meet thine own."

For many that remains enough. For others it can be only a beginning. In the teachings of Jesus, love of God stands before love of neighbor, and in that disturbing sequence is the insight that again and again has inspired man on a spiritual quest. There are signs in our day that the quest so long laid aside is again reviving. The increase in church attendance, spectacular conversions, the testimonials of returning soldiers and sailors, are interesting if not conclusive signs of a religious awakening. So, too, are the reports of some great scientists. "The most beautiful thing we can experience", Albert Einstein has written, "is the mysterious. It is the source of all true art and science. He to whom this emotion is a stranger, who can no longer pause to wonder and stand in rapt awe, is as good as dead. His eyes are closed." Today men are coming to life, their eyes are opening. There is the dawn of a new realization that the wars that need to be waged unremittingly are the great wars of the spirit, through which men struggle against their own egotism and ignorance into progressively greater insight and stature—the wars to which Jesus referred when he said: "My peace I give unto you" and "I came not to send peace but a sword."—Fortune, Jan., 1946.*

*Reprinted through the kind permission of the editors of *Fortune.*

Scientific News and Notes of Academy Interest

Items for this column are solicited from all Academy members. For inclusion in any given issue they should be in the editor's hands at least three weeks before our publication dates, namely the fifteenth of March, June, September and December.

April 2, 3 and 4, all Academy members should recall, will mark the 79th meeting of our organization. The meetings, held this year at Lawrence, will be well attended according to present indications and all members should make plans to attend this meeting of the oldest learned society in the state.

In an effort to get the *Transactions* back on schedule, this issue is somewhat shorter than usual. Scarcity of paper and of labor are constant hindrances to prompt publication and ones for which there seem to be no immediate relief. Contributors to the *Transactions* can also aid prompt publication by the immediate return of proof—within 24 hours of receipt if possible—and by sending in news items as soon as they occur.

Since our December issue was published, we report with deep regret the death of the two following members of the Academy, one who was nearing the century mark in age and the other, in the prime of life:

Dr. Lyman C. Wooster died at his home in Emporia on February 1, 1947 in his 98th year. From 1897 until his retirement in 1934 he was a member of the biology staff at Kansas State Teachers College, Emporia, and for 32 years of that time he served as departmental chairman. Dr. Wooster was one of the active workers in the Academy, having served twice as second vice-president, once as first vice-president, and in 1905 as Academy president, besides membership in innumerable committees. If all members of the Academy had been as active and faithful to the Academy as he, the Academy would have exerted far more powerful influence in the scientific affairs of the state than it now does.

Dr. Bert Nash, a member of the Academy since 1930, died suddenly at Lawrence, Kansas, on February 18, after addressing an audience the previous evening, being stricken with cerebral hemorrhage during the course of the address. Dr. Nash was active in the new organized psychology section of the Academy, his special interests dealing with the under-privileged children of the state. He had been a member of the staff of the University of Kansas since 1930 and previous to that was a staff member at Kansas State College, Emporia. He was in his 48th year at the time of his death.

The scarcity of college and university teachers is prevalent in all schools of the state, as it is elsewhere. During the present semester, the head of the department of athletics at Baker Uni-

versity, Baldwin, and his assistant, Messrs. Carl Spear and Jackson J. Austin, were pressed into duty in teaching courses in hygiene and physiology. Large enrollments everywhere are requiring added assistance and more extensive duties from all qualified members of their various staffs.

Dr. Hobart M. Smith, long a member of the Academy, has recently been appointed as assistant professor of zoology at the University of Illinois. For the past year he has been serving in the Texas wildlife service at Texas A. and M. College, College Station, Texas.

Professor Edith E. Larson, for the past several years a member of the department of biology at Washburn University, Topeka, has accepted a position on the biology staff at the University of North Dakota, Grand Forks. Professor Larson began her duties at Grand Forks with the beginning of the present semester.

Dr. David N. Hume, assistant professor of chemistry at the University of Kansas, has resigned his position to accept a similar position at the Massachusetts Institute of Technology, Boston. Dr. Hume has been at Kansas for the greater part of the past two years.

A new map of Kansas is available from the Superintendent of Documents, Washington, D. C. at a cost of sixty cents. The map, drawn to a scale of 10 miles to the inch, shows all postoffices in the state, shows how each office is supplied with mail, gives county boundaries and names the principal drainage features. It does not show highways nor railroads save those that carry mail. In ordering this map, it should be designated as the "post route map of Kansas."

For readers of the *Transactions* who are concerned with the scenic and cultural aspects of the Southwest, *Arizona Highways*, a monthly magazine of large format, should prove intensely interesting. Every issue is profusely and magnificently illustrated, both in black and white and in color. The January, 1947, issue for example, contains over two dozen beautifully reproduced color illustrations of Arizona cacti. In addition, articles on Arizona museums, the Joshua Tree, and several Arizona scenic areas are included. Published by the Arizona Highway Department, Phoenix, the subscription price is a very modest $2.00 a year or single issues are 35 cents.

The ninth in our series of brief reviews of research centers in the Kansas area describes the Tribune Agricultural Experiment Station. The following account was prepared for the *Transactions* by Mr. Elbert B. Macy, editor of the State Agricultural Experiment Station. Mr. Macy writes:

Midway between the Smoky Hill and Arkansas rivers in Greeley county, 16 miles from the Colorado line, is located the Tribune Branch Agricultural Experiment Station. This branch of the Kansas Agricultural Experiment Station was established in 1911 by the thirty-fourth

Kansas legislature. It includes about 110 acres of land typical of the high plains of western Kansas.

The Tribune district in its original state was a grazing region with buffalo and grama grasses the prevalent type of vegetation. The quality of this pasture is good but the carrying capacity is relatively low, being about 15 acres per head. Best grazing is during the late spring and early summer months. During much of the year, consequently, only a few animals can be maintained on the native vegetation.

The importance of growing feed in this region has long been realized. Need for information in this regard led to establishment of the station and has guided much of its work. The situation has changed as more and more of the native sod has been broken. Now that about 75 per cent of the land is under cultivation, the station should determine the kind and amount of supplemental pasture needed to maintain adequate livestock in the region for a balanced farm program.

It is important, too, to maintain the winter wheat projects so that information on rate and date of seeding the best adapted varieties of this main crop of the region will be available to farmers.

Crop yields vary from year to year because of great differences in rainfall. Average rainfall at Tribune for the last 34 years has been 16.73 inches. The driest year was 1934, with 7.76 inches, and the wettest was 1915 with 33.39 inches. More than three-fourths of the annual precipitation occurs from April to September, during the season when it is most beneficial to crops. Much of it falls in showers of less than one-half inch, however, which are ordinarily ineffective for plant growth.

Average length of the growing season is 159 days, the longest being 181 days in 1913 and 1922 and the shortest being 134 days in 1946. May 2 is the average date of the last killing frost in the spring, and October 9 is average for the earliest killing frost in the fall. Extreme dates for killing frosts were May 22, 1931 and September 23, 1946.

Work with winter wheat at the present time includes rates and dates of seeding many varieties after summer fallow and after a crop. The station is also making investigations on the time of starting summer fallow for winter wheat and the effect on yields of basin listing summer fallow for winter wheat.

Similar work is being done on sorghums. Different dates of planting, both after summer fallow and after a crop, are being tested, and the effects of basin listing under both conditions are being studied.

Most of the work with corn now is varietal testing, along with projects on date of seeding and width of rows.

Popcorn tests have been run in recent years. A vegetable garden is planted each year, and several varieties of potatoes are regularly tested. Home-produced food projects include fruit, too, as an orchard has been established to test varieties of plums, cherries, and other fruits for adaptability to the area.

Several members of the Kansas Academy of Science are participating in arranging the program, and will appear as speakers at the Conference on Exceptional Children to be held in Topeka, Kansas, Wednesday and Thursday, April 9 and 10. The Conference is being sponsored by the State Department of Education and the State Teachers Association. Its purpose is to develop a greater interest in children who deviate in any way from the normal, and to promote a more comprehensive program in the public schools and in other areas for providing adequate services for the special needs of children in Kansas. An article by Dr. H. B. Reed, Academy member of Fort Hays Kansas State College, in the December issue of the *Transactions* emphasized the need for meeting this problem in Kansas.

Drs. G. E. Abernathy and J. M. Jewett of the Kansas State Geological Survey are the authors of the chapter on Kansas coal mines and beds published by the McGraw-Hill Book Company in the *Keystone Coal Buyers Manual,* 1946.

Dr. J. Ralph Wells, head of the biology department at Kansas State Teachers College in Pittsburg, has been appointed as a member of the program committee to make plans for the third National Conference on Health in Colleges, to be held May 7 to 10, at the Hotel New Yorker, in New York City. This conference is sponsored mainly by the American Student Health Association.

Mr. Parley Dennis, formerly of the Independence, Kansas, Junior College has resigned to accept a position in the department of botany, Michigan State College, East Lansing. Mr. Dennis began his work at Michigan State with the beginning of the current semester.

Dr. Ernest Griswold, Mr. Paul Gilles, and Mr. William E. McEwen have been added to the staff of the department of chemistry, University of Kansas, and will begin work at the University in September, 1947. Dr. Griswold received his doctorate in chemistry from Kansas in 1934, and since then has been a member of the chemistry staff at the University of South Dakota. Mr. Gilles and Mr. McEwen will receive their doctorates at California and Columbia, respectively, in June; both have been employed in the past few years on the Manhattan project. Dr. Griswold comes to the University as associate professor and the other two men as assistant professors.

Andrew Schoeppel, former governor of Kansas, was one of several speakers to appear on the program at the Science-Industry - Agriculture Conference held at Kansas State Teachers College in Pittsburg, March 17 and 18. Other speakers who accepted invitations to appear on the program included Lou Holland of Kansas City, former manager of the smaller war plants corporation; Dr. F. F. Elliott, chief of the bureau of agricultural economics for the United States department of agriculture, Washington, D. C.; Dr.

H. F. Myers, head of the department of agronomy at Kansas State College in Manhattan; F. B. Ross of the College of Emporia; Warren Blazier, personnel director of Beech Aircraft Corporation in Wichita; Mr. Harold Vagtborg, president of Midwest Research Institute of Kansas City; Dr. John Frye, executive director of the Kansas State Geological Survey, of Lawrence; Joe E. Culpepper, Spencer Chemical Company, Kansas City; Maurice Fager, assistant director of the Kansas Industrial Development Commission in Topeka; and Nelson F. Rogers of the United States forestry service. Dr. L. C. Heckert, head of the department of physical science at the College, acted as program chairman for the conference which was sponsored by the College, Pittsburg Chamber of Commerce, and Kansas State Chamber of Commerce.

Dr. Philip S. Riggs, director of the Crane Observatory, Washburn University, Topeka, has initiated a new plan for open-house programs at the Observatory. Regular visiting periods will be held on the first and third Fridays of each month from 8:30 P. M. until 10 P. M., except during April and May when open-house hours will be from 9:30 until 10 P. M. Organized groups can make appointments for the hour preceding the time for the general public on open-house nights. Visitors from members of the Topeka community and elsewhere are cordially invited on open-house nights. The Observatory will not be open during inclement weather.

Dr. Edwin O. Stene, of the bureau of government research, University of Kansas, and a frequent contributor to these *Transactions* in the past several years, is spending the present semester at Harvard University, Cambridge, in a post-doctoral fellowship in human relations in the Graduate School of Business.

The Museum of Natural History, University of Kansas, has for the past year sponsored a program of archaeological research in connection with the recently established position of assistant curator of anthropology. To date, activity has been confined to preliminary field surveys and study of existing collections in the eastern half of the state. This work and previous field work of the Smithsonian Institution in the state are encouraging, as their results indicate that research opportunities are plentiful. Salvage operations in basins to be flooded by projected dams or those under construction constitute the most urgent problems at present. Many archaeological sites are located in the threatened areas, and the Museum hopes to have an active program of excavation under way during the summer season.

Dr. E. H. Herrick, a member of the department of zoology, Kansas State College, Manhattan, has been granted leave from March 15 to June 15 to serve as lecturer in endocrinology at the University of Tennessee.

Dr. Elsa Mulethaler of Berne, Switzerland, will be guest inves-

tigator in parasitology for a few weeks during the spring at Kansas State College, Manhattan. Dr. Mulethaler is especially interested in culturing larvae of domestic animal parasites and has been engaged in research during the past months at the Rockefeller Institute, Princeton, N. J. and at the U. S. Agriculture Research Center, Beltsville, Md.

The Bureau of Government Research, University of Kansas, Lawrence, has been actively engaged in publishing the results of study and research on the political institutions of Kansas. Bulletins published by the Bureau may be secured by addressing Dr. Ethan P. Allen, Director, Bureau of Government Research, University of Kansas, Lawrence. Among the recent publications of the Bureau may be listed:

Governmental Agencies of the State of Kansas, 1861-1946, Bessie E. Wilder, 1946, 128 pages. This bulletin includes a brief legislative history of some 563 state agencies in the period indicated by the title. An account of the Kansas Academy of Science will be found on page 7.

Legislative Procedure in Kansas, Frederick H. Guild and Clyde F. Snider, 1946, 79 pages. This bulletin is a revision of one first published in 1931 and is a description of the law-making process as followed in actual practice by the Kansas Legislature. It offers the citizen of the state a readable explanation of the course of legislation from its inception until its final inclusion as part of the statutory law of Kansas.

The Life of a Bill, Rhoten A. Smith, 1946, 25 pages, is a briefer and more popularized account than the bulletin described directly above. An interesting two-page diagram summarizes much of the information in the bulletin.

Fiscal Kansas, J. D. Morgan, no date, 99 pages. This bulletin gives a brief pictorial and statistical summary of state finances for periods ranging from 1930 or 1934 until 1946. It will answer briefly the questions, "How much money does Kansas get each year?" "Where does the money come from?" "What does the state do with money received?" "How do the finances and taxes of Kansas compare with those of other states?" The statements made are brief and the illustrations used are interesting and helpful.

Dr. E. R. Hall and Messrs. Russell Camp and Howard Westman, of the Museum of Natural History, University of Kansas, left in February for Costa Rica where they collaborated with the University of Costa Rica in a collecting expedition in that country. The Kansas group gave instruction to the Costa Ricans in methods of collection as well as participating in the collecting expedition itself. Among the unusual specimens collected was a red-colored opossum. The University party expects to return to the campus by April first.

Mr. Leon Lungstrom, who received his master's degree at Kansas State College, Manhat-

tan, is now serving as part-time instructor in biology at Bethany College, Lindsborg. The remainder of his time Mr. Lundstrom is devoting to research on a doctorate at Kansas State College.

Messrs. G. E. Abernathy and J. M. Jewett of the Kansas Geological Survey are the authors of a brief article in the annual petroleum number of the *Mines Magazine, November,* 1946, "Water Flooding Oil Formations in Kansas."

Dr. J. Harlan Johnson, who did field work in Kansas in 1940 under the sponsorship of the Kansas Geological Survey, has recently published the results of his work in Kansas and elsewhere "Lime-secreting Algae from the Pennsylvanian and Permian of Kansas" in the *Geology Society of America Bulletin,* vol. 57, December, 1946. In this work. based on collections, among others, from 74 stratigraphic units in 196 Kansas localities, it was found that algae locally were very important rock builders. Conclusions concerning the general character of algae deposits, the ecology of the lime-secreting algae and the relation of algae deposits to cyclothems are of special value and interest. Dr. Johnson is now a member of the staff at the Colorado School of Mines, Golden.

Dr. Raymond Moore, research director of the State Geological Survey, University of Kansas, left March 18 for a month's paleontological research in the universities and museums of the East. Dr. Moore expects to attend the annual meeting of the Association of American State Geologists, to be held in Washington late in March, before his return to the University.

Coal Resources of the Wabaunsee Group, Walter H. Schoewe, State Geological Survey, bulletin 63, 144 pages, diagrams, photographs and maps, describes present mining operations, reserves, and quality of the Wabaunsee group coals. These coals occur in an irregular but continuous strip 10 or 20 miles wide across the State from Brown County to Chautauqua County. According to this report about 12,000,000 tons of coal have been produced from these rocks.

The various coal beds of the group that have been mined commercially are described and their geographic distribution, stratigraphic position, thickness, and physical and chemical characteristics are discussed. The history of the early development is noted, mining methods are discussed, the mines are listed, and the estimated tonnage of coal reserves is given by beds.

The Wabaunsee group coals also are treated by counties, including Atchison, Brown, Chautauqua, Coffey, Cowley, Doniphan, Elk, Greenwood, Jackson, Jefferson, Lyon, Nemaha, Osage, Pottawatomie, Shawnee, and Wabaunsee. According to the report about 186,000,000 tons of proved coal remain in the Wabaunsee group in Kansas, an amount which would assure production for 50 years at the present mining rate. The Wabaunsee group also contains approximately 3,700,000,000 tons of potential reserve coal.

Copies of this report, Bulletin

63, may be obtained for a mailing charge of 25 cents by addressing the Geological Survey offices at the University of Kansas, Lawrence.

Recent publications of the State Geological Survey include: *Ground-Water Conditions in Elm Creek Valley, Barber County, Kansas,* Charles C. Williams and Charles K. Bayne, Ground-water analyses by Howard Stoltenberg. Bulletin 64, Part 3, pp. 77-124, diagrams, photographs and maps, September, 1946. Price, 10 cents.

Cretaceous Stratigraphy of the Belvidere Area, Kiowa County, Kansas, Bruce F. Latta, Bulletin 64, Part 6, pp. 217-260, diagrams, photographs and maps, December, 1946. Price, 10 cents.

Copies of these bulletins, at the nominal publication price listed, can be obtained by addressing The Director, State Geological Survey, University of Kansas, Lawrence, Kansas.

The popular idea of scientific investigation is a vehement, aimless collection of little facts, collected as a bower bird collects shells and pebbles, in methodical little rows, and out of this process, in some manner unknown to the popular mind, certain conjuring tricks —the celebrated "wonders of science"—in a sort of accidental way emerge. The popular conception of all discovery is accident. But you will know that the essential thing in the scientific process is not the collection of facts, but the analysis of facts. Facts are the raw material and not the substance of science. It is analysis that has given us all ordered knowledge, and you know that the aim and the test and the justification of the scientific process is not a marketable conjuring trick, but prophecy. Until a scientific theory yields confident forecasts you know it is unsound and tentative; it is mere theorizing, as evanescent as art talk or the phantoms politicians talk about. The splendid body of gravitational astronomy, for example, establishes itself upon the certain forecast of stellar movements, and you would absolutely refuse to believe its amazing assertions if it were not for these same unerring forecasts. The whole body of medical science aims, and claims the ability, to diagnose. Meteorology constantly and persistently aims at prophesy, and it will never stand in a place of honor until it can certainly foretell. The chemist forecasts elements before he meets them—it is very properly his boast— and the splendid manner in which the mind of Clerk Maxwell reached in front of all experiments and foretold those things that Marconi has materialized is familiar to us all.—H. G. Wells in *The Discovery of the Future,* 1913.

A Survey of the Fossil Vertebrates of Kansas

Part IV: Birds

H. H. LANE
University of Kansas, Lawrence.

Despite the fact that birds have long been among the most common vertebrates, their fossil remains are very rare and are, therefore, highly prized when found. The rarity of avian fossils is due in part to the tree-dwelling habit, so that when overtaken by death their bodies drop to the ground and have slight chance of burial before destruction. Even water-birds, because of the lightness and buoyancy of their bodies, float rather than sink after death and so rarely find burial before disintegration. As a rule, fossil bird remains consist mostly of the ends of the long bones of legs and wings, which have been chewed off and scattered by some scavenger. Extremely rare are those cases where the entire skeleton of a bird, or even the major part of it, has been quickly interred and preserved.

The earliest known birds in Kansas are found in the Niobrara chalk, upper Cretaceous (Gulfian) deposits of the western part of the state, perhaps more of them from Gove, Logan and Wallace Counties than anywhere else. Old as they are, however, these are not the oldest known, for the upper Jurassic at Solenhofen in Bavaria, southern Germany, has yielded three specimens—one of them a single feather!—notable for an astonishing mixture of reptilian and avian characters. One of these, practically complete except that the skull is missing, is in the British Museum of Natural History in London. Another, with the skull, *was* in the Natural History Museum in Berlin, but is reported to have been destroyed by the bombing to which that institution was subjected. While similar in many respects, these two specimens were sufficiently unlike to be assigned to different genera—the specimen in London is called *Archaeopteryx,* while that formerly in Berlin was known as *Archaeornis.*

Both these genera had rather short, incompletely developed wings with which there were on either hand a thumb and two other free fingers, each provided with a *claw,* and the whole well adapted for clasping twigs or small limbs as they climbed about in the bushes or trees. There were *teeth* in both the upper and lower jaws, but probably no horny beak. Feathers, too, may have been lacking on the head and parts of the body, though the legs, as well as the wings,

bore large flight feathers—*i.e.*, they were almost *four-winged*, rather than merely *two-winged*. The tail was long and decidedly lizard-like, except that it was provided with large feathers, of which one pair was inserted at each joint between the twenty-one successive vertebrae.

Marsh and a party of his students from Yale University collected the first specimens of fossil birds from Kansas in 1870. These remains were fragmentary and at first were not recognized to be *birds*. The teeth were described in 1872 by Marsh as those of a reptile, called by him *Colonosaurus mudgei;* they were later proven by more complete remains to have belonged to a bird now known as *Ichthyornis dispar*. In succeeding years more complete specimens were collected by Marsh and others working for him. The most important specimen that came to light in those early years was one found by Professor Budge, of Manhattan, near "Sugar Bowl Mound, in northwestern Kansas" (possibly Ellsworth Hill, north of Ellsworth) in 1872. This is the type of *Ichthyornis dispar* and presented the first evidence of *teeth* in birds ever known. The publication in October, 1872, of this discovery occasioned wide-spread interest on that account.

During succeeding years large numbers of fossil bird remains were collected in Kansas, mostly for Marsh, by Mudge, Brous, Cooper, Guild, and F. H. and S. W. Williston. Charles Sternberg, Sr., and H. T. Martin also collected bird remains from the Niobrara Cretaceous of this state. Twelve or more of these specimens are in the University of Kansas Museum of Vertebrate Paleontology, at Lawrence. One of these is unique and noteworthy in showing impressions of the scutes over the tarso-metatarsal region, as well as of some of its feathers.

Marsh, in his monograph on the "Odontornithes", published in 1880, lists all the birds from the Cretaceous deposits of North America then known under nine genera and twenty species. Nearly all the species are from the eastern slope of the Rocky Mountains, and nearly all of them have been found in western Kansas; the rest are from Texas. Birds from somewhat later strata of the Cretaceous have been found in New Jersey, but these mostly or all represent other genera. All American Cretaceous beds in which bird remains have been found are *marine* deposits; and the birds preserved in them are *all aquatic* species. No bird remains have yet been found in deposits of the Comanchean (=lower Cretaceous), nor from the Jurassic anywhere in North America, with one doubtful

exception. Most of the species described by Marsh were based upon very fragmentary material, so that the collection of more complete remains has served only to reduce Marsh's list to about a dozen species, eleven of which are recorded from Kansas. These are all more distinct from the Jurassic *Archaeopteryx* of Europe than they are from modern birds, despite the fact that the former had teeth while the latter do not. The presence or absence of teeth is really a matter of only subordinate importance.

An abbreviated table of classification of birds, as follows, suffices for our purposes here:

Classification of Birds

CLASS AVES
- SUBCLASS I. ARCHAEORNITHES—primitive European birds.
  - Family Archaeopterygidae
    - Genera: *Archaeopteryx* and *Archaeornis*—Jurassic
- SUBCLASS II. NEORNITHES—true birds; cosmopolitan.
  - Superorder A. Odontognathae—American toothed birds; upper Cretaceous.
    - Order 1. Hesperornithiformes
      - Family a. Hesperornithidae
        - Genera: *Hesperornis* and *Hargeria*
      - Family b. Baptornithidae
        - Genus: *Baptornis*
    - Order 2. Ichthyornithiformes
      - Family a. Ichthyornithidae
        - Genus: *Ichthyornis*
      - Family b. Apatornithidae
        - Genus: *Apatornis*
  - Superorder B. Neognathae—all modern birds

The type genus of the Order Hesperornithiformes is *Hesperornis,* "the bird of the West", first described by Marsh in January, 1872. As originally recognized by that author the genus was loosely defined and is now divided into two, *Hesperornis* and *Hargeria,* on the basis of well marked anatomical differences. Of the three species attributed by Marsh to *Hesperornis,* the best known and most common of all is *Hesperornis regalis,* (Fig. 1), of which practically the complete skeleton is known. Basing his account on Marsh's description and figures, as well as upon the unique material in the University of Kansas Museum, Williston notes that this "was a bird measuring about six feet from point of bill to the tip of the feet when outstretched, or standing about three feet high. It was

an aquatic bird, covered with soft feathers, wholly wingless, the vestigial wing-bones probably being buried beneath the skin. The legs were strong and moderately long, and attached to the pelvis in such a way that the feet and tarsal portion of the legs must have stood out nearly at right angles to the body, like a pair of oars. The bones of the foot were so articulated with those of the leg that the foot was turned edgewise as it was brought forward, thus offering the least possible resistance to the water; while on the backward stroke the foot was turned to strike the water flatwise, thus providing

Restoration of Hesperornis made by Melvin Douglas under the direction of H. H. Lane, in Dyche Museum, K. U. x 1/25.

the maximum propulsive power. The long, narrow head was carried on a long, flexible neck, and was provided with a long tapering horny beak, carrying small but effective conical teeth set firmly in a groove in the jaw. The upper teeth were fourteen in number and were set in the back part of the jaw, while the thirty-three teeth on each side in the mandible formed a complete series. The jaws were united in front by a ligament, permitting considerable mobility in swallowing the prey, which certainly consisted of small fishes caught in diving. The bones of the body were solid throughout, not hollow as in most living birds. The sternum had no keel, but was flat like that of an ostrich. The vertebrae and skeleton aside from the teeth were similar to those of modern birds."

Marsh found that "the teeth of *Hesperornis* were gradually replaced by successional teeth, and this took place in a manner very

similar to that in some reptiles. The germ of the young tooth was formed on the inner side of the fang [*i.e.*, the root] of the tooth in use, and, as it increased in size, a pit for its reception was here gradually made by absorption. The old tooth at last became undermined, and was expelled by the new one, which occupied the same position, the number of teeth thus remaining the same." These teeth have conical, pointed but recurved crowns, covered with smooth enamel, and in form closely resemble those of the mosasaurian reptiles.

The vertebrae of the neck and trunk regions of *Hesperornis* are essentially like those of modern birds in all their more important features. The long, slender neck contained 17 vertebrae, while 6 others continued the series through the body to the sacrum. The sacrum comprised 15 coössified vertebrae, while the tail held 12 more, making a total for the entire vertebral column of 49—an unusually large number even for a modern bird.

The breastbone (*sternum*), about 8 inches long and more than 6 inches in greatest width, is a weak, thin, flat bone utterly devoid of a keel—in itself a character sufficient to mark *Hesperornis* as flightless. The shoulder-blade (*scapula*) is a small, slender, somewhat curved bone which lay in a nearly horizontal position on the shoulder region. In *Hesperornis regalis*, it was about 5½ inches long. The "wishbone" (*clavicles*) is represented by *two separate* bones, unlike those in any recent bird. Of the wing-bones only the *humerus* has been found and it is vestigial; often, apparently, it was lacking altogether. The ribs, 9 pairs in all, are hardly to be distinguished from those of modern birds. The first three pairs of ribs were cervical, articulating with the last three neck vertebrae, but with their distal ends free. The other 6 pairs of ribs are all well developed and are connected with the breastbone through *sternal ribs*. Ribs 3 to 8 inclusive carry *uncinate* processes.

The hip-bones (*pelvis*) of *Hesperornis* are more distinctly reptilian in form than those in any modern bird. A striking peculiarity is seen in the relations of the two *ilia*, the dorsal margins of which are greatly arched and united in the median line so as to roof over nearly the whole sacrum. The *acetabulum* differs from that in all other known birds since it is closed internally by bone, except for a foramen that perforates its inner wall, a condition recalling that in crocodiles. There is a well-defined, nearly circular rim around the acetabulum, dorsal to which there is a large *anti-trochanter*, an articular surface to which was applied the neck of the femur. The

three pelvic bones (*ilium, ischium,* and *pubis*) of *Hesperornis* are firmly coössified as in recent birds.

The tail of *Hesperornis regalis* in structure is unlike that found in other birds. It was composed of 12 vertebrae, a greater number than is found in any recent bird, several of which in the posterior half of the tail carry very long, horizontally expanded transverse processes which restricted lateral motion and clearly indicate that the tail was moved mostly up-and-down, evidently an adaptation to diving.

The bones of the legs and feet in *Hesperornis* are more primitive, *i.e.*, more reptile-like, than those in any recent diving bird. The femur is relatively shorter and stouter than in any other known bird, living or fossil, except possibly some of the giant birds of the Cenozoic. A striking feature is the presence of a large surface covering the whole proximal end of the femur, except the head, which articulates with the anti-trochanter of the ilium. The largest bone in the skeleton of *Hesperornis* is the *tibia,* or shin-bone, with a length of 13 to 14 inches. The *fibula* is 10 inches long or about three-fourths the length of the tibia and is much more slender. The second, third and fourth *metatarsals* are fused into a stout, transversely compressed *tarso-metatarsal* bone nearly six inches long, of which the huge fourth metatarsal forms by far the largest part. The first toe is of normal size; the fifth is altogether lacking. Marsh calls attention to the highly adaptive nature of the whole limb and foot in *Hesperornis,* noting that "the plane of motion for the whole limb, which above was coincident with the axes of the femur and tibia, was continued below through this element of the tarso-metatarsal, and down through the fourth, or outer, digit, which it supported. In this structure of *Hesperornis,* so admirably adapted for swimming, we have an example of the same kind of specialized modification which has prepared the foot of the ostrich, among recent birds, and the horse among mammals, for extreme speed on land."

In the feet of *Hesperornis* the fourth or outer toe is the dominant one, being three or four times as powerful as the adjoining middle one, or indeed, as the other three combined; the phalanges are short and thick with the terminal ones more or less pointed.

Since *Hesperornis* was a thoroughly aquatic bird, its habits were doubtless much the same as those of a loon or grebe, except that it was flightless and hence likely never came out on land except possibly to nest. Even that may not have been necessary, since it could have made large rafts of floating seaweeds to support its

eggs during incubation. Its food undoubtedly consisted of fishes, of which there was great abundance and variety in the Cretaceous sea. "*Hesperornis* was an admirable diver, while the long neck with its capabilities of rapid flexure, and the long slender jaws armed with sharp, recurved teeth formed together a perfect instrument for the capture and retention of the most agile fish" (Marsh).

Among all its aquatic adaptations, *Hesperornis* had a unique device in its tail, which in the number of its vertebrae, in its length and unusual breadth differs from that of any other known bird, and certainly was indispensible in steering and diving. This tail apparently could only be raised or lowered, never turned from side to side. *Hesperornis* was truly so highly specialized that it stands well apart from all other known birds, and yet it lived for a long period of time. Conditions of life in the Cretaceous sea on the whole must have been most favorable. Its food was abundant and no doubt easily obtained; its enemies on land were probably few and in the air it had none; in the sea, however, there were the dangerous, pugnaceous mosasaurs and plesiosaurs. Whether they brought about the extinction of these birds, or whether reptile and bird both perished as the result of some geological and climatic change, we do not know. In any event, all the great reptiles and all these archaic types of birds became extinct by the close of the upper Cretaceous.

Marsh's genus *Baptornis* differs but little from *Hesperornis*, the chief distinction being found in the small size of its outer metatarsal.

The second well marked and well known genus of Cretaceous birds from Kansas is *Ichthyornis*, which, as Williston so strikingly remarks, "was as different from *Hesperornis* as a dove is from an ostrich." Its wings were relatively large and powerful, and its breast-bone had a well-developed keel from which the muscles of flight took their origin. The several species are all small and much resembled the modern terns in form and habits. Their bones were hollow; their jaws toothed, indicating that they too fed upon small fishes or other small animals found in the sea. Their vertebrae were peculiar, unlike those of any other known bird, the two ends of the centra being gently concave. In most other respects *Ichthyornis* did not differ to any great extent from the flying girds of today.

The commonest as well as most completely known species is *Ichthyornis dispar* which Marsh described in 1872. The type

specimen was collected by Mudge and is, "perhaps, the most complete specimen of this group that has ever been found, and the first of any known birds that showed the presence of teeth in the jaws" (Williston). *I. victor,* described by Marsh in June, 1876, from a specimen collected by Dr. H. A. Brous on the Smoky Hill River, is now known from nearly fifty specimens. It does not differ from *I. dispar* enough to warrant further description here. *I. agilis, I. anceps,* and *I. tener* were described from fragmentary material and may all be valid species. *I. validus* was collected by Williston on the Solomon River in 1877. The genus *Apatornis* was based on a specimen previously described by Marsh as *Ichthyornis celer.* The two are very similar.

The name *Ichthyornis* was suggested to Marsh by the *biconcave* vertebrae peculiar to these birds, which though not so deep do somewhat resemble the vertebrae of a fish (*ichthyos,* a fish, and *ornis,* bird).

"Because *Hesperornis* was a swimming bird, and *Ichthyornis* a bird of powerful flight, skimming over the waters after the manner of the petrel, they have been more subject to fossilization than the strictly land-inhabiting birds were. Certainly there were many other species and genera of birds in existence at the time when these lived, since the great difference between the two forms could not have been attained without the development of many other forms. Of these, however, we have very few or no remains. Whether all birds contemporary with them were toothed or not it is impossible to say, but the probability is that they were" (Williston).

To the SUPERORDER NEOGNATHAE belong all the modern or typical birds, with which every one is more or less familiar. Of these eleven orders have yielded fossil representatives from Kansas, and doubtless many more remain to be collected or, perhaps, merely to be identified from the large amount of fragmentary material in our museums. Most Neognathae that occur as fossils in Kansas have been described by Dr. Alexander Wetmore, Secretary of the Smithsonian Institution.

The *Order Colymbiformes,* which includes the grebes, has yielded *Colymbus nigricollis* (Brehm), the Eared Grebe, from the Edson beds, middle Pliocene, Sherman County, Kansas. At least two other specimens are in the collection of the University of Kansas (KUMVP, Nos. 4484 and 4652) belonging to undetermined species of the genus *Colymbus,* which came from the Rex-

road fauna, upper Pliocene of Meade County.

The *Order Ciconiiformes,* comprising the herons, storks and allied forms, is represented by an uncertain species of the family Threskiornithidae. It too is from the Rexroad fauna, upper Pliocene of Meade County and is catalogued under the number 4741 in the Kansas University Museum of Natural History, department of Vertebrate Paleontology.

The *Order Anseriformes,* which includes the swans, geese and ducks, has yielded two species belonging to the family *Anatidae.* These are: (1) *Nettion bunkeri* (type: KUMVP, No. 3982), from the Rexroad fauna, Ogallala group, late Blancan age, upper Pliocene, Meade County, Kansas. "Except for heavier size, it is a close counter-part of the Green-winged Teal, *Nettion carolinense.*" And (2) *Charitonetta albeola* (Linnaeus), the Bufflehead. This too is from the same locality and fauna as *Nettion bunkeri.* It is in the University of Kansas Museum (KUMVP, No. 3984) and constitutes the first record of this species in the Pliocene. Five to seven other species of Anatidae are represented by only fragments from the same formation but are not specifically identifiable.

The *Order Falconiformes,* comprising the vultures, hawks and falcons, has yielded two species of the Family *Accipitridae.* These are: (1) *Proictinia gilmorei* Schufeldt, from the lower Pliocene (Loup Fork formation), of Long Island, Phillips County, Kansas, the type of which is in the American Museum of Natural History in New York City. And (2) an undetermined species of the genus *Buteo,* evidently a "large red-tailed hawk," from the Rexroad fauna, upper Pliocene, of Meade County, Kansas.

The *Order Galliformes,* which includes the pheasants, quails, chickens, turkeys, and many others living today, has presented at least three species from Kansas. The family *Phasianidae* which comprises the partridges, quail and pheasants, is represented by two specimens of *Colinus hibbardi* (type: KUMVP, No. 3981 and paratype: No. 3997), from the upper Pliocene of Meade County. It is a "bobwhite" decidedly larger than the living *Colinus virginianus.** A second family, the *Meleagrididae,* or turkeys, has yielded two species, both from the Rexroad fauna, upper Pliocene of Meade County, Kansas. The first is *Meleagris gallopavo* Linnaeus, the well-known "Wild Turkey" of the United States. This is the first record of this species from the Pliocene. The second is an unidenti-

**Colinus eatoni* Shufeldt, described from an unknown geological horizon in western Kansas may be some oscinine Passeriform bird, possibly an Icterid, or a Fringillid. "The species, therefore, is to be removed from the genus Colinus" (Wetmore).

fied species of turkey, (KUMVP, No. 3993), or turkey-like bird of rather small size. It differs from living turkeys "but its generic identity is uncertain".

The *Order Gruiformes,* or cranes, rails, coots, etc., is represented by three species, one a crane and the other two a rail and a coot. The crane (KUMVP, No. 3757), named *Grus nannoides* by Wetmore and Martin, came from the middle Pliocene, Ogallala formation, Edson beds, Sherman County, Kansas. The authors remark that it is "similar to the living *Grus canadensis* (Linnaeus), the Little Brown Crane, but decidedly smaller, less than two-thirds as large."

The rail (*Rallus prenticei* Wetmore) is from the Rexroad fauna, upper Pliocene of Meade County. The type (KUMVP, No. 3865) is described by Wetmore as "a bird slightly larger than the living Virginia Rail, *Rallus limicola.* Apparently it was common in this locality as its remains are among the most abundant of those preserved." It is also represented by KUMVP, Nos. 3866, 3867, 3869, 3870, 3871 and 3872. The coot is the living species, *Fulica americana* Gmelin. It too is from the Rexroad fauna, upper Pliocene, Meade County, and is represented by two specimens (KUMVP, Nos. 3994 and 3988). "This species has been recorded widely in the North American Pleistocene from Florida and Texas to Oregon and California, and is here reported for the first time from the Pliocene" (Wetmore).

The *Order Charadriiformes* includes a great variety of shorebirds such as the snipe and sandpipers, as well as the gulls and terns. The family *Scolopacidae* is represented by a fossil sandpiper (KUMVP, No. 4488), unnamed but thought by Wetmore to be related to *Pisobia fuscicollis.* It comes from the Rexroad fauna, upper Pliocene of Meade County. The second family, the *Laridae,* includes the gulls and terns and is represented by an unidentified species of the genus *Sterna* (KUMVP, No. 3989), a tern about the size of the living Forster's Tern, *Sterna forsteri,* also from the Rexroad fauna, upper Pliocene of Meade County. This specimen was also one reported by Wetmore.

The *Order Columbiformes* is made up of the pigeons and doves. One fossil species is reported by Wetmore from the Rexroad fauna, upper Pliocene of Meade County and this (KUMVP, No. 3995) is the common living Mourning Dove, *Zenaidura macroura* (Linnaeus). According to Wetmore "the mourning dove has been found in Pleistocene deposits in Pinellas County, Florida,

and at McKittrick and Rancho La Brea, California, but is here first recorded from the Pliocene. The size of the fossil is that of male examples of the modern bird."

The *Order Psittaciformes* seems out of place in Kansas, for it includes the parrots and macaws. Yet the Rexroad fauna, upper Pliocene of Meade County has yielded a specimen which, according to Wetmore, "represents a bird smaller than the Thick-billed Parrot, *Rhynchopsitta pachyrhyncha* and larger than the White-fronted Parrot, *Amazona albifrons,* but except for this there is not much that may be said about it. . . There is no question but that it represents an undescribed species, but the material is too fragmentary to allow proper allocation except to family" (*Psittacidae*).

The *Order Passeriformes* includes all the so-called perching birds. Besides several unidentified species of *Fringillidae,* the sparrows and buntings, and one Icterid, there are a number of specimens in the University of Kansas Museum, all from the Rexroad fauna, upper Pliocène of Meade County, including some of the *Compsothlypidae,* and all representing the sub-order *Passeres.* Previous to the collection of this series, a bunting (*Palaeostruthus hatcheri*) was reported many years ago by Shufeldt from the Miocene, near Long Island, Phillips County, Kansas, the type of which is in the American Museum of Natural History in New York City.

Bibliography

Marsh, O. C., 1880: Odontornithes: A Monograph of the Extinct Toothed Birds of North America, Report Geol. Expl. 40th Parallel, pp. 201., plates.

Wetmore, Alexander, 1940: A Systematic Classification for the Birds of the World, Smithsonian Miscel. Collections, vol. 99, No. 7, Publ. No. 3592.

———, 1944: Remains of Birds from the Rexroad Fauna of the Upper Pliocene of Kansas, K.U. Sci. Bull., vol. 30, Part 1, No. 9.

Wetmore, A. and Martin, H. T., 1930: A Fossil Crane from the Pliocene of Kansas, Condor, vol. 32, pp. 62-63.

Williston, S. W., 1898: Birds [of the Upper Cretaceous], Univ. Geol. Survey of Kansas, vol. 4, Paleontology, Part I, pp. 43-53, Plates V to VIII.

Ecological Comparisons of the Plains Prairie-Dog and the Zuni Species

THEO. H. SCHEFFER
U. S. Biological Survey (retired) Puyallup, Wash.

To those who have worked with rodent control or known the plains and the mountain parks as a naturalist, a comparison of the habits and especially the social behavior of the Plains prairie-dog and the Zuni species should be of particular interest.

The Zuni prairie-dog, *Cynomys gunnisoni zuniensis,* is restricted as a subspecies to the corners of the four states of our South-

FIG. 1.—The Zuni prairie-dog posing near burrow entrance. These little animals make no pretense of clearing their "town sites" of concealing vegetation, as does the Plains species.

west—Colorado, Arizona, Utah and New Mexico—that meet at a common point. The greater range is in west-central New Mexico and in north-central Arizona. It was in the latter region, about the San Francisco Mountains and Flagstaff, Arizona, that we made our observations on the Zuni species. There these little animals had adapted their ways of life to conditions of mesa and slope at altitudes of 7,000 to 8,500 feet. The winters are cold and snow-laden, the summer and autumn cool and bracing and otherwise delightful except for the violent thunderstorms of mid-afternoon in July and

Transactions Kansas Academy of Science, Vol. 49, No. 4, 1947.

August. At night the stars are dazzling points of light over Lowell Observatory. The studies of the Plains prairie-dog were made in western Kansas while we were connected with Kansas State College, Manhattan, and later with the Federal Bureau of Biological Survey.

To one who has long known the common prairie-dog the call note of the Zuni species has a flavor of foreign accent; perhaps only a local dialect but distinctively different, though not akin to the more prolonged whistle of the burrowing squirrels in general. It is a short "bark" with something of a metallic timbre. The pose of the animal is the same as that of the Plains prairie-dog but its pelage markings are somewhat more contrasting than in our dog of the plains. As one enters upon the premises of a colonial habitat one misses the closer communal life and the frantic scurrying to cover of the Kansas prairie-dog. The animals are seen running only here and there and later encountered in hiding at or near their burrows, into which they vanish on closer approach. In respect to the more scattered burrows and to retreat at discretion they resemble the Columbian ground squirrel of the Spokane country in our Pacific Northwest. The attendant surroundings are much the same—malpais terrain, with small or larger open parks and associated stands of clean-growth pine. Comparison lacks here, however, the scattered pinon and juniper of the Arizona mesas. Of course one does not usually comprehend the entire communal activity at a glance; for there are obstructions to view in the way of grass tufts, small shrubs and, locally, a stone or a stump that will conceal many a rodent citizen. Those who are acquainted with the short-grass plains of western Kansas will remember that the dog-town sites are as free of obstructions as a well manicured suburban lawn. At the shrill bark of a single observant "dog" the whole colony is on the *qui vive*.

The burrow entrances of the Zuni prairie-dog more commonly lack the crater-like mounds that dot the dog towns of the plains, serving both as sentinel posts and to keep out surface water. The excavated earth is, in the former case, simply scratched out into a ramped heap and not worked over into a cratered hillock. On excavation also we found the burrows of the Arizona prairie-dog to be more slanting in descent, shallower in the subsoil, and lacking in the turning bay so characteristic of the diggings of the plains dog, at a depth of perhaps two feet from the surface. In these bays the dog can retire briefly, to reappear presently with an eye to the horizon for suspected danger, or out of mere curiosity—a trait common to squirrels. Descent to the home nest of the plains dog would be more laborious of return, for the burrows are often quite

steep and come from lower levels of as much as eight or ten feet. On the other hand, nests of the Zuni prairie-dog that we excavated were reached at depths of two and one-half to five and one-half feet. They were composed entirely of pine needles, though grass was accessible in the immediate vicinity. The Plains prairie-dog composes itself in nest balls mainly of dried buffalo grass and grama grasses, which is about all that can be obtained in its foraging. With both species short "prospect" burrows are found, ending blindly, and old, perhaps very old burrows now abandoned and packed with earth and domestic garbage of former years. The same is true of abandoned nesting chambers. And once, in a burrow excavation on the

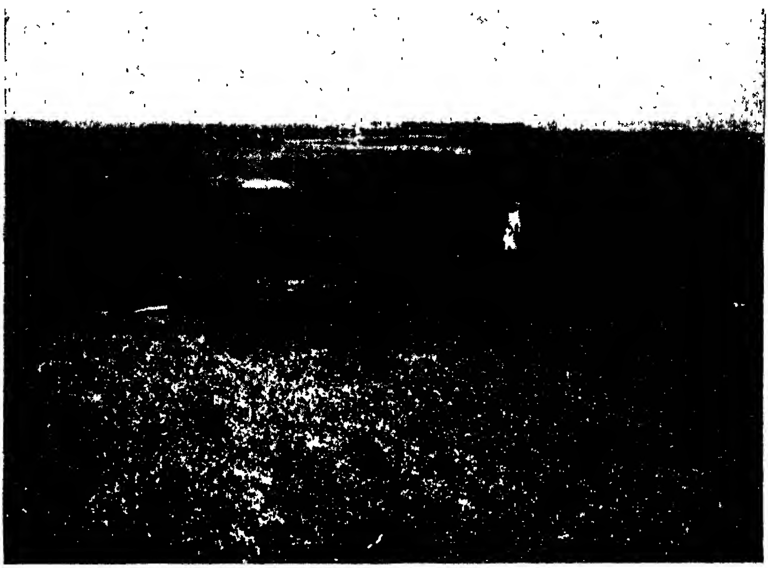


FIG. 2.—A typical mound and pose of the Plains prairie-dog in a fenced pasture in central Kansas, but colony scattered and partially deserted.

mesa, we dug up a perfect *metate* though we are not led to assume that it had been used to save the rodent's molars.

So far as our observation goes, neither of the two species of prairie-dog ever hibernates in the full sense that this word connotes; that is, the winter sleep is not greatly prolonged nor probably profound. We have seen the Kansas prairie-dog out on bright cold days in mid-winter and have found paths of the Zuni dog leading to burrow entrances which led down through snow drifts. This, however, was in late March. We have not had opportunity to follow this species through a winter season. Neither have we found food

stores in any excavation. The Plains prairie-dog can forage at any time of year, weather permitting, and find nutritious grasses—green stage or field-cured hay. The same is probably true of the Zuni dog.

The communal life of the Zuni dog is less marked than that of its plains cousin, and for that reason less attractive and interesting to an observer. This follows no doubt from the less compact colonies, which could act in unison, and from the greater isolation of the individual on the obstructed townsite. Neither the rattlesnake nor the little owl, so frequently mentioned by writers of early western travel as co-dwellers in the Kansas dog towns, were found commonly, if at all, in the Zuni dog colonies at these higher altitudes. Jays are there

FIG. 3.—A colony of the Zuni prairie-dog on the Arizona mesas. Burrows of these animals are considerably shallower than those of the Plains prairie-dog and usually lack the crater entrance.

at times—birds which will poke around out of curiosity or self interest anywhere that other creatures, feathered or furred, manifest activity. And Horned-Larks were about much of the time, to brighten the day with breeze-sped song.

Since any form of life tends to spread to any and all habitats adapted to its type, the prairie-dog must provide for loss by accident and termination of life span, as well as make provision for extension of its kind. This instinct of reproduction has operated to produce but small broods in the Zuni prairie dog. Three to four young are born each spring, in late April and early May, on the Coconino plateau of northern Arizona. This record is based on examination of

nine females that were found to be pregnant. Five females in the lot examined had apparently not mated and appeared to be immature at this season. Ten females examined May 15 to 28 were suckling young, numbers in each case not apparent. The first young were seen at the mouths of the maternal burrows on June 3. The commonest number observed at any time was three, which seems to verify the

FIG. 4.—The Plains prairie-dog scratches up turf to increase the height of an eroded mound. Burrows from these cratered hillocks may descend as much as ten feet or more, and off horizontally, to the nests of fine dry grass.

pregnancy count. The following data concerns comparison of the sexes in the Zuni prairie-dog, based on specimens collected at Flagstaff, Arizona, April 19 to June 4:

Average weight of 20 males	1 lb. 4 3/5 oz.
Average weight of 25 females	1 lb. 3 3/5 oz.
Average length of 20 males	342.6 mm.
Average length of 25 females	329.5 mm.
Average tail length of 20 males	60 mm.
Average tail length of 25 females	58 2/3 mm.
Average foot length of 20 males	58 mm.
Average foot length of 25 females	56 mm.

In general, it may be inferred that such differences as we may note in physical characters and behaviour of the Zuni prairie-dog

and of the Plains prairie-dog draw largely from altitude, ground cover, and barrier isolation.

May we close with the expressed desire and expectancy that naturalists and nature lovers of tomorrow be not deprived entirely of pleasing contacts with these social little animals of our plains and mountain parks. There has been too much of the extermination thought in the background of organized means of repression, for the benefit of farmers and stockmen who very often are true conservationists themselves and would be the first to miss these denizens of the short-grass. Man's primaeval claim to dominate all animal life did not contemplate the destruction of a race, nor should his modern and more civilized claim assert new and revised sanctions. And yet we have seen the slogan "Get the last dog" in the state by a certain zero hour. All creatures of the wild have had, or still have a certain value to us in the niche they fill. It goes without least argument that these niches must be narrowed as we encroach upon them with our essential occupations of life; but there always has been, always will be space for the survival of the lowly.

Living and Fossil Pupillidae (Gastropoda) of the Sanborn Area, Northwestern Kansas[1]

DOROTHEA S. FRANZEN
Department of Zoology, Kansas University, Lawrence.

ABSTRACT: The pupillid faunule of the Sanborn Pleistocene area, northwestern Kansas, is divided into three parts: 1. Species occurring here only as fossils including *Vertigo elatior* Sterki, *Vertigo gouldii paradoxa* Sterki, *Vertigo modesta* Say, *Vertigo tridentata* Wolf, *Pupilla muscorum* (Linnaeus), *Pupilla blandi* Morse, *Columella alticola* (Müller); 2. Species not found as fossils including *Gastrocopta contracta* (Say), *Gastrocopta holzingeri* (Sterki), *Gastrocopta cristata* (Pilsbry and Vanatta), *Gastrocopta procera* (Gould), *Vertigo ovata* Say, and *Pupoides hordaceus* Gabb; 3. Living species found also as fossils including *Gastrocopta armifera* (Say), *Gastrocopta tappaniana* (C. B. Adams), and *Pupoides marginatus* (Say).

Present day ecological features of the Sanborn area are discussed. Probable climatic conditions in northwestern Kansas during the time of Sanborn Pleistocene depositions are inferred on the basis of knowledge of ecological conditions under which pupillids, in group 1 above, live today in other areas remote from the Sanborn area.

The Sanborn Formation is composed of Pleistocene deposits which occur over the greater part of northwestern Kansas. Early studies include those made by Robert Hay (1895, pp. 535-588) and by Erasmus Haworth (1899, pp. 247-281). A more recent series of studies was begun by Elias (1931) and has been continued by others.

Although Elias named the formation, he has not designated a type section. Because he devoted special study to northwest Cheyenne County, and mentions exposed sections which there attain a thickness of approximately 180 feet, one of these may conveniently be thought of as the type section. Elias derived the name for the formation from Sanborn, Nebraska, the town nearest to northwestern Cheyenne County. Later he applied the name to deposits in Rawlins and Decatur Counties, Kansas, (Hibbard, Frye, Leonard,

[1]I wish to express my appreciation to the Kansas Academy of Science for the Grant-in-Aid which made the field trip possible; to Professor A. Byron Leonard, of the Department of Zoology, for direction in my studies; to Professor W. H. Horr, of the Department of Botany, for assistance in the discussion of the characteristic flora; and to Professor John Frye, U.S.G.S., for helpful suggestions on geology.

1944, p. 3). "The name is intended as a substitute for the old terms 'Tertiary marl' or 'Plains marl' introduced for this formation by Robert Hay" (Elias, idem, p. 163).

Although Elias spoke of the Sanborn Formation as being "widely distributed on the divides in western Kansas," he does not designate its extent. However, he does discuss the occurrence of Sanborn deposits in Cheyenne and Wallace counties (Elias, idem, p. 163).

John C. Frye, Claude W. Hibbard, and Byron Leonard made further geological studies of the Sanborn deposits in the course of which they collected and identified vertebrate and molluscan fossils, respectively.

Leonard and Frye (1943, pp. 454-460) studied the Pleistocene deposits, including the contained gastropods of Rawlins, Decatur, Sherman, Thomas, Sheridan, and Logan counties and included certain of the deposits in the Sanborn Formation. Hibbard, Frye, and Leonard (1944, p. 6) included upper Pleistocene deposits as far east as western Jewell County in this formation. However, the areal distribution of the Sanborn Formation has not been ascertained.

The Sanborn Formation is a part of "the large area in central, northcentral, and northwestern Kansas that contains extensive nonglacial deposits consisting mostly of valley fills (including high level abandoned valleys), terrace deposits, and extensive and widespread deposits of eolian loess that mantle both the water laid Pleistocene deposits and the older rocks" (Frye, 1945, p. 80). According to Elias (Elias, idem, p. 163) the Sanborn is a deposit of "loess with some gravel and sand at the base." Frye, after studying deposits exposed in Cheyenne, Rawlins, and Decatur counties, stated, "The Sanborn consists predominantly of dirty yellow and gray-tan loess, but in some places it is very sandy and, locally, contains coarse sand and gravel at the base. In most exposures it is impossible to recognize any distinct bedding or zoning of the formation. It is graditional from top to bottom" (Leonard and Frye, 1943, p. 454).

The upper gray loess ranges in color from ashy gray to light cream-tan, and is composed of massive, unconsolidated, well sorted silt and very fine sand. Westward of Decatur County the loess is somewhat calcareous but concretions and nodules are rare in contrast to their progressively greater abundance in the depositions as one proceeds eastward of Decatur County (Hibbard, Frye, and Leonard, 1944, pp. 8-10). Leonard and Frye (1943, p. 455) divided the Sanborn Formation into three lateral facies which represent, ". . . three distinct environments in which the sediments were deposited, and in

many cases these sediments can be distinguished from one another. . . . Thus, the three facies of the Sanborn in this area seem to be (1) terrace silts and gravels, (2) upland eolian loess . . . , and (3) small areas of valley slope and alluvial deposits, which probably consist of deposits of (1) or (2), or both, that have been redeposited. The upland loess phase, wherever observed is silt; the terrace deposits are sand and locally show some bedding; the valley slope or alluvial phase, in some places, is poorly sorted but may contain any of the characteristics of either of the other two phases."

The Sanborn formation, in many places, overlies unconformably the Ogallala Formation (middle Pliocene), and is everywhere mantled by the Recent soil zone. Frye considers the age of the formation as probably middle and late Pleistocene (Leonard and Frye, 1943, p. 461).

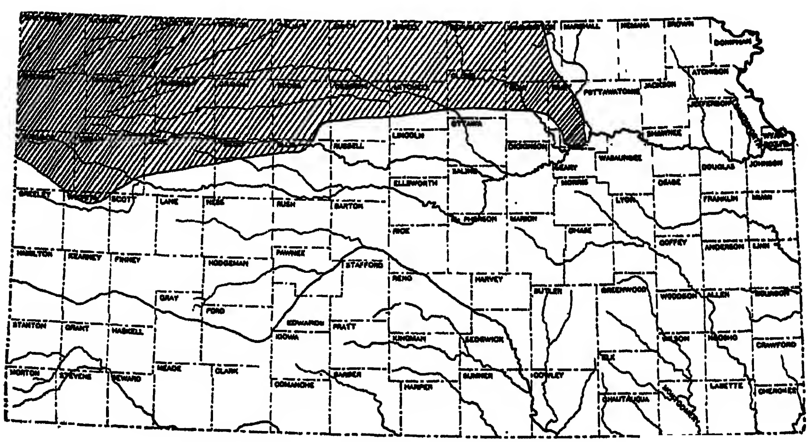
Kansas, a state in the Mississippi Valley, lies in the High Plains Border regions (Fenneman, 1931, p. 6). It is a part of the plain which slopes eastward from the Rocky Mountains. The degree of inclination is indicated by the altitudes of several localities. The altitudes of two western points are 3288 feet at St. Francis, Cheyenne County, and 3685 feet at Goodland, Sherman County. The altitude at Colby, Thomas County, only thirty-eight miles east of Goodland, is 500 feet less, 3138 feet. Western Osborn County, 135 miles east of Colby is only 2100 feet in elevation, and eastern Mitchell County is but 1300 feet above sea level.

Generally speaking, the topography is that of a plains region, but there are some irregularities. The streams head in Sherman and Thomas counties, the most elevated area. The channels are wide, but shallow upstream, and increase in depth and width in the downstream courses. Low resistance of the sandy surface soil and underlying Quarternary deposits to cutting action of the stream and to general weathering, accounts for the general retreat of the slopes. Stream channels in Sherman County as well as in Thomas county flow only after heavy rains and therefore have not cut deeply enough to obtain water from the Tertiary strata. Consequently these streams are of an ephemeral nature (Frye, 1945 a, pp. 12-13).

Depressions of various sizes, such as occur in Thomas County, form another topographical feature of this area. Frye (1945 a, p. 29) says, "The most distinctive aspect of the county probably is the large number of depressions that dot the surface of the uplands and in some places occur on intermediate levels. These depressions are of various sizes but in no case do they assume the size of the

large solutional-subsidence areas of southwestern Kansas. . . . The origin of these depressions presents a perplexing problem."

East and northeast of Thomas County the stream channels become progressively wider and deeper. Small stream channels are cut as deeply as 10-15 feet. In some localities, for example in Rooks County, rapid stream-erosion has resulted in narrow channels, often as deep as 100 feet. The North and South Forks of the Solomon River course eastward from Thomas County to Mitchell County where they join to form the Solomon River. These two tributaries run parallel within 15-20 miles of each other. The upland between these two channels is 300 feet above the floor of the valley of either stream, which produces a rolling contour. Tributaries of the Republican River, such as Beaver Creek, Sappa Creek, and Prairie Dog Creek, head as ephemeral streams in Thomas County. Farther downstream, in Rawlins, Decatur and Norton counties, these tributaries have cut deeply enough through the Tertiary to draw underground water; consequently they flow throughout the year. In some localities, such as in Cheyenne County, artesian springs result in local ponds and continuously flowing small streams.



Map of Kansas—Shading Indicates Area Considered.

Another topographical feature of the area of Kansas under consideration is a series of terraces, probably remnants of Pleistocene stream channels. These are indicative of a former drainage pattern. In contrast to the elevated terraces is the deeply eroded area of northwestern Cheyenne County where streams have channeled into the Sanborn deposits. The result of this erosion is a series of canyons and bluffs in which the Sanborn Formation is exposed.

The climate of northwestern Kansas is characteristic of a mid-continental, semi-arid region; temperatures fluctuate widely both daily and seasonally. Temperature readings taken at two localities in the area concerned are shown in tables 1 and 2. As may be seen, the later summer months are characterized by hot days and cool nights. Although temperatures drop to a sub-zero level in several of the winter months and below freezing late in the spring of some years, the extremely cold weather is not continuous throughout the season.

Most precipitation usually occurs in early summer (see tables 1 and 2). During the later summer months the rainfall is light, the

TABLE 1.—*Meteorological Data of Goodland, Sherman County, Kansas.*

Alt.	Year	Annual Mean Temp.	Highest Temp.		Lowest Temp.		Precipitation	Greatest Monthly Precip.		Lowest Monthly Precip.	
3,685′	1934	56.6° F.	108° F.	July 13	–1° F.	Feb. 26	10.52″	2.16″	June	.04″	Oct.
	1935	53.9	106	July 30	–15	Jan. 21	14.26	3.41	Aug.	.02	Jan.
	1936	53.5	110	July 23	–22	Feb. 8	12.83	4.14	May	.05	Nov.
	1937	52.5	108	Aug. 9	–14	Jan. 8	12.84	4.43	June	.20	Nov.
	1938	55.3	108	Aug. 2	–5	Jan. 30	17.06	4.44	May	.11	Oct.
	1939	55.	109	July 20	–6	Feb. 10	16.11	2.64	June	.00	Nov.
	1940	52.	111	July 25	–10	Jan. 18	20.48	4.69	Sept.	.35	Feb.
	1941	52.1	99	July 9	–4	Dec. 28	28.75	7.34	July	.24	Nov.
	1942	50.8	103	July 13	–15	Jan. 4	25.41	5.43	June	.48	Mar.
	1943	52.5	107	Aug. 23	–16	Jan. 19	18.13	4.92	June	.20	Nov.
Average		53.42	106.9		–10.8		17.639	4.36		.169	

temperature high and the relative humidity low. Therefore, the rate of evaporation is high which partly accounts for the ephemeral nature of the streams in the localities where the streams have not cut deeply enough to draw underground water or where they are not fed by artesian springs. In the winter months snow falls intermittently. Since the extremely low temperatures are not prolonged, the ground does not remain covered with snow through the season.

The wind blows uninhibited over the open plains. In winter, wind frequently accompanies snow, which at times results in blizzards. In the spring and early summer, rain storms are not unusual. Occasional tornadoes, sweeping across the country, are destructive.

The vegetation is characteristic of a semi-arid, windswept region.

TABLE 2.—*Meteorological Data of Phillipsburg, Phillips County, Kansas.*

Alt.	Year	Annual Mean Temp.	Highest Temp.		Lowest Temp.		Precipitation	Greatest Monthly Precip.		Lowest Monthly Precip.	
1,939′	1934	58.0° F.	117° F.	July 13	–14° F.	Jan. 26	16.08″	4.91″	June	.21″	Jan.
	1935	55.2	113	July 10	–11	Jan. 21	21.76	5.19	May	.09	Jan.
	1936	55.2	120	July 24	–19	Feb. 8	15.32	4.48	Sept.	.08	Nov.
	1937	53.1	112	Aug. 2	–18	Jan. 23	16.23	4.02	June	.07	Dec.
	1938	56.8	111	Aug. 5	–4	Jan. 31	18.36	4.67	May	Trace	Dec.
	1939	57.1	113	July 20	–12	Feb. 10	13.36	3.59	June	Trace	June
	1940	53.2	116	July 25	–15	Jan. 18	17.90	3.01	May	.44	June
	1941	53.8	105	July 9	–3	Dec. 28	31.89	8.69	June	.61	Nov.
	1942	53.0	106	July 16	–13	Jan. 5	25.69	5.97	June	.15	Jan.
	1943	53.5	109	Aug. 24	–16	Jan. 19	19.40	4.45	June	Trace	Oct.
Average		54.89	112.2		–12.5		19.59	4.89		.235	

Plants of this area have certain features which enable them to survive in this environment. Among such features are: Low growth form, strong root system, possession of serrated leaves which reduce the resistance to wind, and hirsute, spinous, or heavy, viscid leaves which probably decrease the amount of evaporation.

The prairie is the most dominant of the several types of associations into which the vegetation can be divided. Buffalo grass, *Buchloe dactyloides* (Nutt.) Engelm., is the predominating grass of the prairie. Widespread, but not locally abundant in this association are two important legumes, *Callirrhoe* sp., and *Petalostemon* sp. Cacti, composites and other weeds, all native, grow on the open prairie. Gramma grasses are scattered throughout the area and often form the dominant vegetation in sandy soil where moisture is available over a prolonged period. Bluestem is present in areas of loose soil and especially in canyons.

In disturbed places such as along the roadsides, a different association obtains. Panic grasses, sandbur, several species of the two families of pigweed, Chenopodiaceae and Amaranthaceae, bullnettle, the cocklebur *Xanthium* sp., and the puncture weed *Tribulus terrestis* L. are common. Russian thistles are plants of the cultivated field, waste ground and especially of areas of moving soil. *Helianthus annus* L., the Kansas sunflower, grows only about eight inches high in a dry season but four to six feet high in a favorable season. In rocky, gravelly, or loose sandy soil, the yucca is a characteristic plant.

The growth of trees and shrubs is limited almost completely to the banks and shores of streams and ponds or places of shallow groundwater. However, in the eastern limits of this area, such as in Smith County, bur oak is a common tree in the canyons. The cedar, *Juniperus virginiana* L., a drought resisting tree, grows in canyons and along north-facing hill slopes. In Norton County the heaviest growth of trees is along the banks of streams as for example, of the Solomon River. Extending westward the tree growth consists mainly of the western variety of the cottonwood, the red and the white elm, box elder, and two species of willows. Honeylocust, hackberry, and ash are found but rarely. Among the trees or on open slopes grow such shrubs as smooth sumac, *Rhus glabra* L., and *Rhus trilobata* Nutt., and the currant, *Ribes odoratum* Wendl. The poison ivy, *Rhus toxicodendron rydbergi* (Small) Garrett, is not to be overlooked. In the ponds the aquatic vegetation is mainly sedges, rushes, pondweeds, and cattails.

In a ten-day period of collecting by the author in June, 1944, Recent aquatic and terrestrial gastropods were obtained from a total of forty-two localities in nineteen counties, from Riley County to the Kansas-Colorado state line. Pupillids were taken from twenty-two localities in fourteen counties. Living specimens were taken whenever possible. However, drift which had been washed down from local slopes was taken in order to get as nearly a complete a collection of the molluscan faunule as possible. Along the Arikaree River, drift was taken from the flood plain. The exact origin of pupillids, as well as other snails, in such drift is difficult to determine.

Although the distribution of pupillids in Kansas is general, local occurrence is dependent upon a moist environment, either in grassland or under leaf mold in timber. *Pupoides marginatus* was collected in northwestern Kansas from moist grass of untimbered slopes of streams where this species lived in association with other pupillids. As far as it was possible to determine from the limited collection, the pupillids other than *P. marginatus* were restricted, in this area, to the wooded slopes, in areas high enough not to be scoured of vegetation and mollusks by flooding during seasonal rains. The slopes along small tributaries support gastropod faunules better than slopes along the main channels where the flood plain is more extensive and the soil more sandy.

The banks of the tributaries of the main streams, and the shores of some of the state lakes in Riley, Mitchell, Graham, Osborn, and Rooks counties, and the timbered slopes near springs in Cheyenne County supported the most abundant pupillid faunules, while no pupillids were found to inhabit barren slopes of ephemeral streams of Thomas and Sherman counties.

Pleistocene mollusks collected from Sanborn deposits by Frye and Hibbard and studies made of them by Leonard,[2] have been drawn upon for this report. Leonard (Leonard and Frye, 1943, pp. 455-460) identified mollusks from Sanborn deposits. These were collected at twenty-five localities in six counties. The collections contained specimens of fifteen species of gastropods; five species of pupillids representing three genera were included. Leonard (Hibbard, Frye, and Leonard, 1944, pp. 12-13) made a further study of gastropods from Sanborn deposits—twenty localities in nine counties. These lots contained twenty-nine species and subspecies belonging to four genera. Frye (unpublished report) has made a further collection of gastropods from Sanborn deposits from fifteen localities in Norton and Wichita counties. From this material,

Leonard identified twenty-two species of gastropods, of which nine species and subspecies belonging to five genera were pupillids.

Of the pupillids collected and under consideration, one group is represented only in Pleistocene deposits, a second only in the Recent fauna, and a third is represented in both the Pleistocene and Recent faunas.

The first group is comprised of pupillids which today live in areas which are generally humid or cool, including more northern ones, or in those of higher altitude where the temperature is lower and the atmosphere more humid than it is in northwestern Kansas at the present time. Pupillids, now extinct in the Sanborn area, are listed below with their present day geographic distributions (Pilsbry, 1916):

Vertigo elatior Sterki: Ohio; north, east, and west of Ohio; mountainous areas of New Mexico.

Vertigo gouldii paradoxa Sterki: Maine, Quebec.

Vertigo modesta Say: Labrador, west to Victoria; New England region.

Vertigo tridentata Wolf: Illinois, north and northwest to New York and Ontario; Colorado, northeastern Kansas; Texas.

The genus *Pupilla* lives in cold and temperate regions, ". . . under wood and stones and among leaves in moderately humid situations" (Pilsbry, V. 26, p. 152).

Pupilla muscorum (Linneaus): Eastern North America; west in Canada, north in Alaska, south in Rocky Mountain Region; Arizona.

Pupilla blandi Morse: Rocky Mountain Region; Montana, New Mexico, Nevada.

Columella alticola (Ingersoll): Alberta, British Columbia, Utah, Wyoming, Colorado, and Arizona; Utah at altitudes of 7500-8000 feet.

The pupillids of this first group occupy regions in which the climatic conditions are unlike those obtaining in northwestern Kansas today. *Vertigo tridentata,* found only as a fossil in northwestern Kansas, lives in an area where the relative humidity is greater than it is in the Sanborn area at the present time. The other species comprising this group live in areas remote from northwestern Kansas. This observation is not in accord with statements cited by Russell (Russell, 1944, pp. 20-21) as he discusses the fauna of the lower Mississippi Valley loess, "Terrestrial snails form an overwhelming

[2]These specimens and all others considered in this report are catalogued in the mollusk collections of the University of Kansas Museum of Natural History.

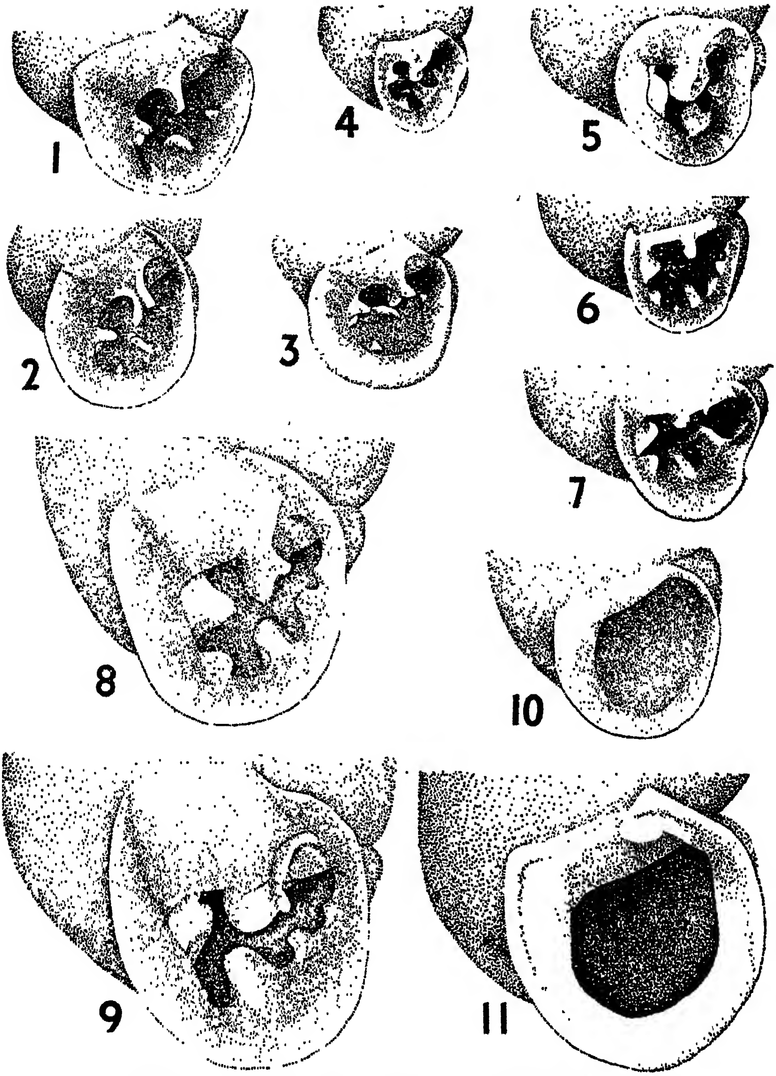


PLATE I.—RECENT PUPILLIDS OF THE SANBORN AREA

Fig. 1.—Gastrocopta cristata (Pilsbry and Vanatta)
Fig. 2.—Gastrocopta procera (Gould)
Fig. 3.—Gastrocopta procera (Gould)
Fig. 4.—Gastrocopta holzingeri (Sterki)
Fig. 5.—Gastrocopta contracta (Say)
Fig. 6.—Gastrocopta tappaniana (C. B. Adams)
Fig. 7.—Vertigo ovata Say
Fig. 8.—Gastrocopta armifera (Say)
Fig. 9.—Gastrocopta armifera (Say)
Fig. 10.—Pupoides hordaceus Gabb
Fig. 11—Pupoides marginatus (Say)

All figures X20

element in the fauna. Most authorities agree that all species are now living. Lyell (1834, p. 120; 1838, p. 84) was first to observe this and first to state that every species now inhabits the immediate vicinity (1849, pp. 150, 156). McGee (1891, p. 471) found this to be the case at Davenport and Muscatine, Iowa. Upham (1895, p. 283), E. H. Barbour (1903), Hay (1914, p. 42), and many others have noted the same thing. Shimek (1896; 1902) emphasizes the point by such statements as: ' "Every species of mollusks which has thus been reported from Iowa, Nebraska, and Missouri is living today, and with three or four exceptions all are found living within the territory covered by the loess' " (1897, p. 33).

The group occupying the area today and not found in the Pleistocene deposits is one that is tolerant of great changes in temperature, semi-arid conditions, and periods of drought. During the hot and dry seasons the pupillids, as well as other gastropods, aestivate in the ground under rocks and piles of debris. The following is a list of species in this group with their general distribution:

Gastrocopta contracta (Say): Canada and eastern United States; South Dakota; Oklahoma. In northwestern Kansas, taken from Riley and Mitchell counties.

Gastrocopta holzingeri (Sterki): Ontario, Canada; United States, western New York, Montana, Illinois, Kansas, New Mexico. In northwestern Kansas from six localities from Mitchell County west to Cheyenne County.

Gastrocopta cristata (Pilsbry and Vanatta): Texas; Arizona, New Mexico; Oklahoma and Kansas; apparently not common in northwestern Kansas.

Gastrocopta procera Gould: Eastern United States, west to Kansas, Oklahoma; south to Alabama and eastern Texas. Its range in northwestern Kansas from Mitchell to Cheyenne counties indicates a general distribution.

Vertigo ovata Say: Labrador and Alaska; Mexico and West Indies. In northwestern Kansas, taken from only two localities.

Pupoides hordaceus (Gabb): New Mexico, Colorado, Arizona. In this collection from northwestern Kansas the only specimen taken was from drift on the flood plain of the Arikaree River in Cheyenne County.

The third group comprises forms found in the Sanborn Pleistocene deposits and also living in the area today. It includes the following species and subspecies:

Gastrocopta armifera (Say): Canada; Eastern United States south to Florida, west to Colorado, New Mexico, mouth of Pecos River, Texas. Of all the Recent pupillids collected from the Sanborn

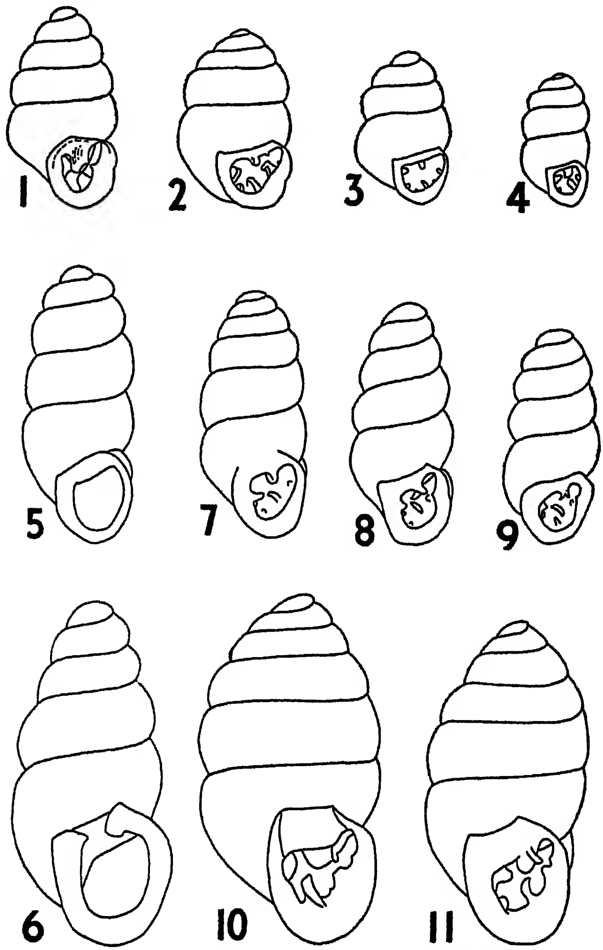


PLATE II.—RECENT PUPILLIDS OF THE SANBORN AREA

Fig. 1.—Gastrocopta contracta (Say)
Fig. 2.—Vertigo ovata Say
Fig. 3.—Gastrocopta tappaniana (C. B. Adams)
Fig. 4.—Gastrocopta holzingeri (Sterki)
Fig. 5.—Pupoides hordeaceus Gabb
Fig. 6.—Pupoides marginatus (Say)
Fig. 7.—Gastrocopta cristata (Pilsbry and Vanatta)
Fig. 8.—Gastrocopta procera (Gould)
Fig. 9.—Gastrocopta procera (Gould)
Fig. 10.—Gastrocopta armifera (Say)
Fig. 11.—Gastrocopta armifera (Say)
All figures X10

area, this one occurred most frequently. It was taken from twenty-one of the twenty-two localities.

Gastrocopta tappaniana (C. B. Adams): Ontario, Maine south to Virginia and Alabama, west to South Dakota, Kansas, Arizona.

Pupoides marginatus (Say): Ontario; Maine to the Gulf of Mexico; Arizona and south to Puerto Rico. It is generally distributed over northwestern Kansas as indicated by the finding of it at twelve localities.

Hanna and Johnston (1913) made a study of the Prairie Dog Creek area near Long Island, Phillips County, Kansas. They list the occurrence of the following pupillids:

Recent forms: *Pupoides marginatus* (Say), *Gastrocopta procera cristata* Pilsbry and Vanatta, *Gastrocopta armifera* (Say), *Gastrocopta holzingeri* Sterki, *Gastrocopta tappaniana* (C. B. Adams.)

Pleistocene forms: *Columella alticola* (Ingersoll), *Columella hasta* (Hanna and Johnston), *Pupilla muscorum* (Linnaeus), *Gastrocopta mcclungi* Hanna and Johnston, *Vertigo modesta* Say, *Vertigo gouldii* (Binney), *Vertigo hannai* Pilsbry, *Pupilla blandi* Morse, *Gastrocopta Holzingeri* Sterki, *Gastrocopta armifera* Say.

Because the localities and strata from which Hanna and Johnston collected are not clearly designated and there is some doubt as to the identity of some of the species reported, these forms are merely listed and are not considered in this study.

Conclusions

Pupillids collected from northwestern Kansas can be placed in three categories: (1) Seven species and subspecies of three genera which are now extinct in this area but have been taken from Sanborn Pleistocene deposits: (2) Six species and subspecies of three genera which live in northwestern Kansas today but have not been taken from the Sanborn Pleistocene deposits; (3) Three species and subspecies of two genera which have been taken from Sanborn Pleistocene deposits and which live in northwestern Kansas at the present time.

Northwestern Kansas today is semi-arid; the annual precipitation averages about twenty inches, and the rate of evaporation is high due to the low relative humidity. In the latter part of the summer, hot winds are not uncommon. The prevalent vegetation is adapted to semi-arid regions.

The present pupillid faunule is composed of species which are tolerant of widely fluctuating and extreme temperatures and a limited amount of rainfall as well as prolonged periods of drought. In contrast, the pupillid faunule limited in this area to the Sanborn Pleistocene deposits is represented today in cooler and more humid regions, and in northern latitudes or in zones of higher altitudes. Therefore the climate in the time of the Sanborn Pleistocene deposition is judged to have been cooler and more humid than it is now.

Literature Cited

Elias, Maxim K., 1931. The Geology of Wallace County, Kansas. State Geo. Surv. of Kans., Bull. 18.

Flora, S. D., 1934-1943. Climatological Data, Kansas Section; U. S. Dept. of Agri. Weather Bureau, Vol. XLVIII, No. 1,—Vol. LVII, No. 13.

Frye, John C. 1945. Problems of Pleistocene Stratigraphy in Central and Western Kansas. The J. of Geol., Vol. LIII, No. 2, pp. 73-93.

————, 1945a. Geology and Ground-water Resources of Thomas County, Kansas. Univ. of Kans. Pub., State Geol. Surv. of Kans., Bull. 59.

Hanna, G. Dallas and Johnston, Edward C., 1913. A Pleistocene Molluscan Fauna from Phillips County, Kansas. The Kans. Univ. Sc. Bull., Vol. VII, No. 3, Jan. 1913, pp. 111-121.

Haworth, Erasmus, 1897. Geology of Underground Water in Western Kansas. In Rept. Board Irrig. Surv. and Experiment for 1895-'96, pp. 247-281.

Hay, Robert, 1895. Water Resources of a Portion of the Great Plains. U.S.G.S. 16th Annual Report, pt. II, pp. 531-588.

Hibbard, Claude W., Frye, John C., and Leonard, A. Byron, 1944. Reconnaissance of Pleistocene Deposits in North-Central Kansas. Univ. of Kans. Pub., State Geol. Sur. of Kans., Bull. 52, pt. 1, pp. 1-28.

Leonard, A. Byron and Frye, John C., 1943. Additional Studies of the Sanborn Formation, Pleistocene, in Northwestern Kansas. Am. J. of Sc., Vol. 241, July, 1943, pp. 453-462.

Russell, Richard Joel, 1944. Lower Mississippi Valley Loess. Bull. of the Geol. Soc. of Am., Vol. 55, pp. 20-21.

Pilsbry, Henry A. Manual of Conchology. Vol. 24, 1916-1918; Vol. 25, 1918-1920; Vol. 26, 1920-1921; Vol. 27, 1922-1926; Vol. 28, 1927-1935; Dept. of Mollusca, Acad. Nat. Sc., Philadelphia.

Species of Birds Added to the Kansas Faunal List Since 1900, With Reference to the First Record[1]

ARTHUR L. GOODRICH,
Kansas State College, Manhattan.

About 1900, two papers were written, which, if studied together, clearly establish the position of Kansas Ornithology at that time. In October, 1897, D. E. Lantz read before the Kansas Academy his paper titled *A Review of Kansas Ornithology.*[2] F. H. Snow submitted to the Academy in January, 1903,[3] a review of his contributions to Kansas Ornithology, a critique of Lantz' paper, and a revised catalogue of birds of Kansas. There does not appear to be in print any exhaustive tabulation of species added to the Kansas list during the last forty-odd years.

This paper is submitted in the belief that a compilation of recent records may be of considerable service to future students of Kansas Ornithology, particularly to those who will in time work out the problems of ranges occupied by many subspecies.

The entries which follow have the sequence of the fourth edition of the A. O. U. Check-List. A few of the technical names do not agree with the Check-List usage, because major revisions of certain groups have occurred since its publication. In so far as possible, quotations are given from the original sources, stressing the first mentioning of the species or subspecies for Kansas. Where such specific statements are not known to the writer, the reference given contains the earliest mention known to him of the species or race in Kansas.

Family Gaviidae

Gavia immer elasson Bishop. Lesser loon. Long, W. S., Observations on the November birds of western Kansas. Kans. Univ. Sci. Bul., 22:225-248 (1935). "I believe this should be referred to *Gavia immer elasson* Bishop."

Gavia stellata (Pontoppidan). Red-throated loon. Gloyd, H. K., Red-throated loon in Kansas. Wilson Bul., 38(2):116-117 (1926). ". . . this capture records a new species for the state."

Family Colymbidae

Colymbus grisegena holboelli (Reinhardt). Holboell's grebe. Evans, Logan, *Colymbus holboelli* in Kansas. Auk, 28(1):107

Transactions Kansas Academy of Science, Vol. 49, No. 4, 1947.

[1]Contribution Number 244 from the Department of Zoology, Kansas State College, Manhattan, Kansas.

[2]Lantz, D. E. A Review of Kansas Ornithology. Kans. Acad. Sci. Trans., 16:244-276.

[3]Snow, F. H. Notes on the Birds of Kansas, and a revised catalogue. Kans. Acad. Sci. Trans., 18:154-176.

(1911). "October 22, 1910, I captured a female Holboell's grebe on the Kansas River near Lawrence."

Family Pelecanidae

Pelecanus occidentalis occidentalis Linnaeus. Eastern brown pelican. Burt, W. H., Three new birds for Kansas. Auk, 44(2): 262 (1927). "A single specimen of this species was found dead after a severe storm . . . 1916 near Parker, Linn County, Kansas."

Family Areidae

Ardea herodias wardi Ridgway. Ward's heron. Oberholser, H. C., Review of the forms of the great blue heron. U. S. Nat. Mus. Proc., 43:531-559 (1913). The author lists one specimen (male) from Kansas. No date nor locality was specified.

Ardea herodias treganzai Court. Treganza's heron. Long, W. S,. Observations on the November birds of western Kansas. Kans. Univ. Sci. Bul., 22:225-248 (1935). "The measurements are too small for anything but Treganza's heron."

Family Threskiornithidae

Ajaia ajaja (Linnaeus). Roseate spoonbill. Lantz, D. E., Statistics about Kansas birds. Kans. Acad. Sci. Trans., 18:151-153 (1901-02). ". . . three additions to the list . . . Roseate Spoonbill. . ." Without further comment, this additional reference is given: Snow, F. H., Catalogue of the birds of Kansas, Kans. Acad. Sci. Trans., 18:164-176 (1901-02). "This species is new to the Kansas Catalogue."

Family Anatidae

Branta canadensis leucopareia (Brandt). Lesser Canada goose. Taverner, P. A., *in* Birds of Canada, Bul. 72, Nat. Mus. Canada, Ottawa, 1934, says that this form is a re-discovery of a type of bird once known as Hutchin's goose. He further states that the form recorded in the third edition of the A. O. U. Check-List as *B. c. hutchinsi* is not the type of bird to which the common name of Hutchin's goose was originally applied. It appears that the race now known under the common name of Hutchin's goose is masquerading under that name. It further appears that Long, W. S., in his Check-list of Kansas birds, Kans. Acad. Sci. Trans. 43:433-456, 1940, seems first to have listed the long-called Hutchin's goose under the subspecific name of *B. c. leucopareia* in Kansas bird literature, and to have retained the common name of Hutchin's goose for a race to which the name was not originally given.

Branta canadensis minima Ridgway. Cackling goose. Downs, Theodore, and John Breukelman, Birds of Lyon County and vicin-

ity. Kans. Acad. Sci. Trans., 44:389-399 (1941). Reports one specimen of cackling goose taken by Dr. G. C. Rinker near Hamilton, Kansas.

Anas rubripes rubripes Brewster. Red-legged black duck. Bunker, C. D., Birds of Kansas. Kans. Univ. Sci. Bul., 7(5):137-158 (1913). "A specimen classified as the Red-legged Black Duck by Mr. G. C. Rinker . . . was collected . . . and loaned to the museum. . ."

Glaucionetta islandica (Gmelin). Barrow's golden-eye. Bunker, C. D., Birds of Kansas. Kans. Univ. Sci. Bul., 7(5):137-158 (1913). "This is a new species for the state."

Clangula hyemalis (Linnaeus). Old-squaw. See references for *Ajaia ajaja,* the roseate spoonbill, above.

Melanitta deglandi (Bonaparte). White-winged scoter. Compton, L. V., The white-winged scoter, a new state record for Kansas. Condor, 33:256 (1931). ". . . the specimen was a new record. . ."

Oidemia americana Swainson. American scoter. Dyche, L. L., A new bird for the Kansas list, taken at Lawrence. Kans. Acad. Sci. Trans., 22:311 (1908). ". . . and added to the University bird collections."

Family Accipitriidae

Parabuteo unicinctus harrisi (Audubon). Harris's hawk. Bunker, C. D., Harris's hawk . . . in Kansas. Auk, 36(2):283 (1919). "So far as I know this hawk has not been reported before from the state."

Family Falconidae

Falco columbarius bendirei Swann. Western pigeon hawk. Long, W. S., Western pigeon hawk in Yucatan and Kansas. Auk, 51(4):515-516 (1934). [A specimen in the K. U. museum taken in 1875, is said to be of this subspecies. Checked by Mr. J. L. Peters of the Museum of Comparative Zoology. Originally identified by Dr. Snow as *F. c. richardsoni.*]

Falco sparverius phalaena (Lesson). Desert sparrow hawk. Bunker, C. D., Birds of Kansas. Kans. Univ. Sci. Bul., 7(5):137-158 (1913). "New to the list."

Family Phasianidae

Colinus virginianus taylori (Lincoln). Western bobwhite. Long, W. S., Observations on the November birds of western Kansas. Kans. Univ. Sci. Bul., 22:225-248 (1935). "The three specimens

taken . . . agree very well with Lincoln's published description of taylori. . ."

Callipepla squamata pallida Brewster. Arizona scaled quail. Burt, W. H., Three new birds for Kansas. Auk, 44(2) :262 (1927). "These three specimens (shot in Morton County, 1926) are, to my knowledge, the only ones taken in the State."

Alectoris graeca Meisner. Chukar. Hans, Fred L. A new game bird in Kansas. *In* 6th Biennial Report, Forestry Fish and Game Commission, Topeka, Kansas. June, 1936. See also: Wall, Roy, Chukar partridge. *In* 7th Biennial Report, Forestry, Fish and Game Commission, Topeka, Kansas. June, 1938. "Two groups of ten birds each were liberated in each of the twelve warden's districts. . ."

Perdix perdix perdix (Linnaeus). European partridge. Travis, D. W. Game-birds distributed. *In* 16th Biennial Report, Kansas Fish and Game Warden, Jan. 1, 1907 to Dec. 31, 1908, Topeka, Kans., 1909,[4] ". . .and 1100 pair (or 2200) of Hungarian partridges have been distributed and liberated over the state."

Phasianus colchicus races and hybrids. "Ring-necked" pheasant. Travis, D. W. Game birds: their propagation and distribution. *In* 15th Biennial Report, Kansas Fish and Game Warden, June 30, 1905 to Jan. 1, 1907, Topeka, Kans., 1907. ". . . 1500 pair (or 3000 birds) have been distributed and liberated. . ."

Family Charadriidae

Arenaria interpres morinella (Linnaeus). Ruddy turnstone. Bunker, C. D. Birds of Kansas. Kans. Univ. Sci. Bul., 7(5) :137-158 (1913). Rinker, G. C., *in* Some rare birds at Hamilton, Kansas, Auk, 31(1) :104-105, 1914, mentions he took a bird of this common name in 1911. He uses the technical name of *Arenaria morinella.*

Family Scolopacidae

Tringa solitaria cinnamomea (Brewster). Western solitary sandpiper. Long, W. S., Three subspecies of birds not previously reported. . . Condor, 37(1):39 (1935). [Four skins of this subspecies examined, three of which also were examined by H. C. Oberholser.]

Catoptrophorus semipalmatus semipalmatus (Gmelin). Eastern willet. Bunker, C. D. Birds of Kansas. Kans. Univ. Sci. Bul., 7(5): 137-158 (1913). "One male was collected in Greenwood County by G. C. Rinker. . ." Rinker, G. C., *in* Some rare birds at Hamilton, Kansas, Auk, 31(1): 104-105, 1914, writes ". . . I do not think there

---

[4]Bibliographic references to this and the following form were supplied by Marguerite P. Jester, Reference Librarian, Kansas State Library, through Louise McNeal, Librarian. Appreciation for this aid is herewith acknowledged.

is a published record for the state." Long, W. S., Check-list of Kansas birds, Kans. Acad. Sci. Trans., 43:433-456, 1940, says "All specimens examined proved to be of the next subspecies [*C. s. inornatus* (Brewster)]."

Limnodromus griseus griseus (Gmelin). Eastern dowitcher. Long, W. S., The dowitcher, a new bird for Kansas. Auk, 51(1): 81 (1934). "So far as I have been able to learn, this is the first recorded occurrence of the Dowitcher in Kansas."

Ereunetes maurii Cabanis. Western sandpiper. Bunker, C. D., Birds of Kansas. Kans. Univ. Sci. Bul., 7(5):137-158 (1913). "New to the list. . ."

Family Recurvirostridae

Himantopus mexicanus (Müller). Black-necked stilt. Bunker, C. D., Birds of Kansas. Kans. Univ. Sci. Bul., 7(5):137-158 (1913). "Added to the list in 1906 by T. H. Griffiths." [This form reported in 1886 by Goss as "seen."]

Family Phalaropidae

Phalaropus fulicarius (Linnaeus). Red phalarope. Dyche, L. L. The red phalarope . . . a new bird for the Kansas list. Kans. Acad. Sci., Trans., 20, Pt. 2:131-132 (1905-06). ". . . killed at Lakeview . . . 1905."

Family Stercorariidae

Stercorarius parasiticus (Linnaeus). Parasitic jaeger. Snow, F. H., Two additions to the bird fauna of Kansas. Auk, 21(2):284 (1904). ". . . is an absolute addition to our avifauna." See also, Snow, F. H., Notes of 1904 on the birds of Kansas. Kans. Acad. Sci. Trans., 19:263 (1903-04). ". . . not having been previously reported . . . is an absolute addition to our avifauna."

Family Laridae

Hydroprogne caspia imperator (Coues). Caspian tern. Compton, L. V., The Caspian tern, a new state record for Kansas. Condor, 34(6):260 (1932). ". . . an adult . . . was killed . . . about five miles east of Lawrence. . ."

Family Columbidae

Zenaidura macroura marginella (Woodhouse). Western mourning dove. Bunker, C. D., Birds of Kansas. Kans. Univ. Sci. Bul., 7(5):137-158 (1913). "A new bird to the list."

Family Cuculidae

Geococcyx californianus (Lesson). Road-runner. [If any birdname has been added and removed from the Kansas lists more than any other, this is probably that name. The inconsistency stems from the points of view of authors, some of whom insist that a skin of a

bird shot in Kansas must exist before the form may be officially recorded, whereas others permit sight records to stand. Both points of view have their advocates.] First sight record: Goss, N. S., Additions to the catalogue of Kansas Birds. Auk, 3(1):112-115 (1886). Goss states that a division superintendent of the A. T. and S. F. railway wrote him in 1884 that he had seen two road-runners 15 miles east of the Colorado-Kansas line. First record of skin: Burt, W. H., Three new birds for Kansas. Auk, 44(2):262 (1927). Burt writes: "... but as far as I know there have been no specimens taken [before] to make the report authentic." Record of first specimen in captivity: Kellogg, V. L., The road-runner in Kansas. Auk, 10(4): 364 (1893). Kellogg notes a specimen captured in Comanche County, kept and made a pet of from December, 1892 to after May, 1893.

Crotophaga sulcirostris sulcirostris Swainson. Groove-billed ani. Snow, F. H., Notes of 1904 on the birds of Kansas. Kans. Acad. Sci. Trans., 19:263 (1903-04). "A specimen . . . was captured . . . about November 1, 1904."

Family Strigidae

Otus asio hasbroucki Ridgway. Hasbrouck's screech owl. Tiemeier, Otto W., Hasbrouck's screech owl from Kansas. Auk, 54(3):391 (1937). Mentions two specimens collected in 1933 and identified by Dr. H. C. Oberholser.

Otus asio aikeni (Brewster). Aiken's screech owl. Bunker, C. D., Birds of Kansas. Kans. Univ. Sci. Bul., 7(5):137-158 (1913). "A new species [*sic*] for the state. . ."

Strix varia alleni Ridgway. Florida barred owl. Long, W. S., Check-list of Kansas birds. Kans. Acad. Sci. Trans., 43:433-456 (1940). [The writer found no previous mention of this race in Kansas except in Long's unpublished Master's thesis, Birds of Kansas, Kansas University Library, dated 1935.]

Family Caprimulgidae

Antrostomus carolinenesis (Gmelin) Chuck-will's-widow. Lantz, D. E., New and rare birds in Kansas. Auk, 16(2):187 (1899). "This is the first record for the State. . ."

Chordeiles minor chapmani Coues. Florida Nighthawk. Long, W. S., Check-list of Kansas birds. Kans. Acad. Sci. Trans., 43:433-456 (1940). [The writer found no earlier record of this race except in Long's unpublished Master's thesis, Birds of Kansas, Kansas University Library, 1935, in which he says "Five . . . prove, on examination to be referrable to the present subspecies."]

Chordeiles minor howelli Oberholser. Howell's nighthawk.

Oberholser, H. C., . . . The Genus Chordeiles Swainson. . . U. S. Nat. Mus. Bul., 86:1-120 (1914). Oberholser lists fourteen dates when specimens of this subspecies were taken in Kansas.

Chordeiles minor sennetti Coues. Sennett's nighthawk. Wetmore, Alexander, Fall notes from eastern Kansas. Condor, 11(5): 154-164 (1909). "This is the first authentic record . . . for the state. . ."

Chordeiles minor hesperis Grinnell. Pacific nighthawk. Oberholser, H. C., . . . The Genus Chordeiles Swainson. . . U. S. Nat. Mus. Bul., 86:1-120 (1914). Oberholser lists within the tabulation of specimens examined the following: "*Kansas.*—Hamilton (Sept. 10, 1913)."

Family Picidae

Colaptes auratus auratus (Linnaeus). Southern flicker. Wetmore, Alexander, Three new records for Kansas. Condor, 17(3): 129 (1915). ". . . apparently [has] not been previously reported from that State."

Ceophloeus pileatus pileatus (Linnaeus). Southern pileated woodpecker. Long, W. S., Check-list of Kansas birds. Kans. Acad. Sci. Trans., 43:433-456 (1940). [The writer found no earlier record of this subspecies except in Long's unpublished Master's thesis, Birds of Kansas, Kansas University Library, 1935.]

Sphyrapicus thyroideus nataliae (Malherbe). Natalie's sapsucker. Long, W. S., Check-list of Kansas birds. Kans. Acad. Sci. Trans., 43:433-456 (1940). Reports a sight record near Concordia, Kansas, in April, 1935.

Dryobates villosus villosus (Linnaeus). Eastern hairy woodpecker. Oberholser, H. C., A revision of the forms of the hairy woodpecker. . . U. S. Nat. Mus. Proc., 40:595-621 (1911). Oberholser, in describing this subspecies, refers to a specimen from Kansas. This *species* seems first to have been identified with Kansas by Baird in 1858.

Dryobates pubescens pubescens (Linnaeus). Southern downy woodpecker. Wetmore, Alexander, Three new records for Kansas. Condor, 17(3):129 (1915). ". . . apparently [has] not been previously reported from that State."

Family Tyrannidae

Empidonax flaviventris (Baird and Baird). Yellow-bellied flycatcher. Long, W. S., Check-list of Kansas birds. Kans. Acad. Sci. Trans., 43-433-456, 1940.

Family Alaudidae

Otocoris alpestris hoyti Bishop. Hoyt's horned lark. Long, W. S., Check list of Kansas birds. Kans. Acad. Sci. Trans., 43:433-456, 1940. Although this is a race of long standing, Long seems first to have applied the name to a Kansas specimen.

Family Corvidae

Cyanocitta cristata cyanotephra Sutton. Sutton, G. M., A new bluejay from the western border of the Great Basin. Auk, 52:176-177, 1935. Fall birds from Lane, Comanche and Norton counties and breeding birds from the eastern part of the state are described as paler than Louisiana and other forms. "It is my present belief that . . . the race ranges throughout Kansas. . ." Certain types formerly known under the name of *C. cristata cristata* may thus become known under a new name.

Aphelocoma californica woodhousei (Baird). Woodhouse's jay. Long, W. S., Observations on the November birds of western Kansas. Kans. Univ. Sci. Bul., 22:225-248, 1935. ". . . has not been reported . . . previous to this time."

Aphelocoma sieberi arizonae (Ridgway). Arizona jay. Keith, B. A., Arizona Jay . . . found in Kansas. Kans. Acad. Sci. Trans., 43:427, 1940.

Family Paridae

Penthestes carolinensis agilis (Sennett). Plumbeous chickadee. Wetmore, Alex., Three new records for Kansas. Condor, 17(3): 129, 1915. ". . . apparently [has] not been previously reported from that State."

Family Sittidae

Sitta carolinensis atkinsi Scott. Florida nuthatch. Long, W. S., Check list of Kansas birds. Kans. Acad. Sci. Trans., 43:433-456, 1940. Long's unpublished Master's thesis, Birds of Kansas, Kansas University Library, 1935, records several skins as ". . . closer to *atkinsi*."

Sitta carolinensis nelsoni Mearns. Rocky Mountain nuthatch. Long, W. S., Observations on the November birds of Western Kansas. Kans. Univ. Sci. Bul., 22:225-248, 1935. "This is the first report of the Rocky Mountain Nuthatch in Kansas."

Family Troglodytidae

Thryomanes bewicki cryptus Oberholser. Texas wren. Bunker, C. D., Birds of Kansas. Kans. Univ. Sci. Bul., 7(5):137-158, 1913. "Not included in Dr. Snow's list."

Thryomanes bewicki niceae Sutton. Nice's wren. Long, W. S., Observations on the November birds of western Kansas. Kans.

Univ. Sci. Bul., 22:225-248, 1935. Long does not specifically state this bird is a new find for Kansas, but appears to be first to use the name since it was proposed by Sutton in 1934 (Auk, 51(2):217-220, 1934).

Family Mimidae

Mimus polyglottos leucopterus (Vigors). Western mockingbird. Bunker, C. D., Birds of Kansas. Kans. Univ. Sci. Bul., 7(5): 137-158, 1913. "New to the list."

Family Turdidae

Turdus migratorius achrusterus (Batchelder). Southern robin. Bunker, C. D., Birds of Kansas. Kans. Univ. Sci. Bul., 7(5):137-158, 1913. "New to the list." See also Wetmore, Alex., Condor, 16(2):92, 1914. ". . . nearest point . . . recorded previously in Van Buren, Arkansas."

Hylocichla guttata sequoiensis (Belding). Sierra hermit thrush. Long, W. S., Check list of Kansas birds. Kans. Acad. Sci. Trans., 43:433-456, 1940. Long makes reference to a specimen taken in 1912. This may be the specimen referred to in Bunker, C. D., Birds of Kansas, Kans. Univ. Sci. Bul., 7(5):137-158, 1913, as *Hylocichla guttata auduboni.*

Hylocichla fuscescens salicicola Ridgway. Willow thrush. Wetmore, Alex., Fall notes from eastern Kansas. Condor, 11(5):154-164, 1909. ". . . those three constitute the only records for the state to my knowledge." See also Bunker, C. D., Birds of Kansas. Kans. Univ. Sci. Bul., 7(5):137-158, 1913. "New to the list."

Sialia mexicana bairdi Ridgway. Chestnut-backed bluebird. Long, W. S., Check list of Kansas birds. Kans. Acad. Sci. Trans., 43:433-456, 1940. The foregoing reference and Long's unpublished Kansas University thesis (1935) record a sight record by a Mr. Shanstrum from Coolidge, Kansas. Shanstrum reported for Coolidge to the *Bird Lore* Christmas census around 1920, but I have been unable to find record of this subspecies in the lists available to me.

Family Laniidae

Lanius borealis invictus Grinnell. Northwestern shrike. Long, W. S., Observations on the November birds of western Kansas. Kans. Univ. Sci. Bul., 22:225-248, 1935.

Lanius ludovicianus migrans Palmer. Migrant shrike. Bunker, C. D., Birds of Kansas. Kans. Univ. Sci. Bul., 7(5):137-158, 1913. "New to the list."

Family Sturnidae

Sturnus vulgaris vulgaris Linnaeus. Starling. Bunker, C. D., The starling in Kansas. Auk, 47(2):256, 1930.

Family Vireonidae

Vireo philadelphicus (Cassin). Philadelphia vireo. Linsdale, Jean, Philadelphia vireo in Kansas. Condor, 28(4):181, 1926. "I know of no published records for the occurrence of this species in Kansas. . ."

Family Compsothlypidae

Vermivora chrysoptera (Linnaeus). Golden-winged warbler. Hall, E. R., Golden-winged warbler in Kansas. Auk, 38:608, 1921. ". . . I collected a Golden-winged Warbler . . . in Douglas County, Kansas."

Dendroica aestiva rubiginosa (Pallas). Alaska yellow warbler. Long, W. S., Alaska yellow warbler in Kansas. Auk, 53:219, 1935. Long records the presence in the Kansas University museum of three skins, taken in 1919, 1921 and 1922.

Dendroica aestiva sonorana Brewster. Sonora yellow warbler. Long, W. S., The Sonora yellow warbler in Kansas. Auk, 53:219-220, 1936. ". . . taken . . . Wallace County, June 24, 1911."

Dendroica tigrina (Gmelin). Cape May warbler. Harris, H., Birds of the Kansas City region. Acad. Sci. St. Louis, Trans., 23:213-371, 1919. ". . . over the State line in Johnson Co., Kansas."

Dendroica chrysoparia Sclater and Salvia. Golden-cheeked warbler. Hilton, D. C., Notes on birds of the Fort Leavenworth Reservation, Kansas. Wilson Bul., 32:80-87, 1920. "One resident pair observed closely from time to time." This species has not been reported as "taken" nor has a skin been reported in any Kansas collection.

Dendroica castanea (Wilson). Bay-breasted warbler. Long, W. S., Check list of Kansas birds. Kans. Acad. Sci. Trans., 43:433-456, 1940. Long records a sight record by P. B. Peabody of Blue Rapids, Kansas, in both the above reference and in his unpublished thesis, Birds of Kansas, 1935, University of Kansas Library. See also: Downs, Theodore, The bay-breasted warbler in Kansas, Auk, 63:597-598, 1946. "A male . . . was obtained on May 14, 1943, , , , seven and one-half miles southwest of Lawrence. . ."

Seiurus noveboracensis noveboracensis (Gmelin). Northern water thrush. Linsdale, Jean, and Hall, E. R., Notes on the birds of Douglas County, Kansas. Wilson Bul., 39:91-105, 1927. "This is believed to be the first record."

Oporornis tolmiei (Townsend). Macgillivray's warbler. Snow F. H., Ten birds new to the avifauna of Kansas. Auk, 24(3):344,

1907.[5] See also Long, W. S., Check list of Kansas birds. Kans. Acad. Sci. Trans., 43:433-456, 1940. This paper records one specimen taken by P. B. Peabody of Blue Rapids, Kansas, in 1923.

Geothlypis trichas brachidactyla (Swainson). Northern yellowthroat. Bunker, C. D., Birds of Kansas. Kans. Univ. Sci. Bul., 7(5):137-158, 1913. The name *Geothlypis trichas* has been in Kansas literature for many years. William Palmer, publishing in The Auk, 17:216-242, 1900, distinguished between the two races recorded here, but the distinction was not accepted by the A. O. U. for its third edition of the Check list.

Geothlypis trichas trichas (Linnaeus). Maryland yellowthroat. Douthitt, Bessie, Migration records for Kansas birds. Wilson Bul., 31:6-20, 1919. See note to preceding form.

Wilsonia pusilla pileolata (Pallas). Northern pileolated warbler. Wetmore, Alex., Fall notes from eastern Kansas. Condor, 11: 54-164, 1909. "To my knowledge this is the first publisht record of the occurrence of this variety within the state."

Family Icteridae

Sturnella magna argutula Bangs. Southern meadowlark. Long, W. S., Check list of Kansas birds. Kans. Acad. Sci. Trans., 43:433-456, 1940. Long also mentions this race in his unpublished thesis, Birds in Kansas, Kansas University Library, 1935.

Agelaius phoeniceus arctolegus Oberholser. Giant red-wing. Bunker, C. D., Birds of Kansas. Kans. Univ. Sci. Bul., 7(5):137-158, 1913. "New to the list."

Agelaius phoeniceus fortis Ridgway. Thick-billed red-wing. Douthitt, Bessie, Migration records for Kansas birds. Wilson Bul., 31:6-20, 1919. Listed, but not stated as new.

Icterus cucullatus nelsoni Ridgway. Arizona hooded oriole. Lincoln, F. C., Arizona hooded oriole in Kansas. Auk, 57:420, 1940. ". . . adds the Arizona Hooded Oriole to the avifauna of Kansas."

Molothrus ater artemisiae Grinnell. Nevada cowbird. Long, W. S., Three subspecies of birds not previously reported . . . Condor, 37(1):39, 1935. "A male in the Goss collection . . . is considered to be intermediate between *artemisiae* and *ater*, but nearer to the former."

Family Fringillidae

Loxia curvirostra neogaea Griscom. Red crossbill. Long, W. S.,

[5]The reference here given is of a paper listing as Kansas birds a series of forms taken along the Colorado-Kansas line. Since it is not apparent that the birds were actually taken on the Kansas side of the border, the forms named have not been included by Bunker or Long as Kansas birds.

Check list of Kansas birds. Kans. Acad. Sci. Trans., 43:433-456, 1940. This is probably the first published use of the name for a Kansas bird since Griscom established the subspecies in 1937.[6] The *form* is not new to the Kansas list, for this is the "common crossbill of eastern North America" (Griscom).

Loxia curvirostra pusilla Gloger. Newfoundland crossbill. Long, W. S., Check list of Kansas birds. Kans. Acad. Sci., Trans., 43:433-456, 1940. This is probably the first published use of the name for a correctly identified Kansas bird since van Rossem wrote in 1934 that the type of *L. pusilla* Gloger represents the Newfoundland crossbill, and is to be known as *L. c. pusilla* Gloger (= *L. c. percna* Bent). The 1935 edition of the A. O. U. Check List associates the name Newfoundland Crossbill with *L. c. percna* Bent. According to the A. O. U. check-list numbers, prior to its 1931 edition specimens named *L. c. pusilla* appeared under the name of *L. c. minor.*

Loxia curvirostra minor (Brehm) Sitka crossbill. Long, W. S., Check list of Kansas birds. Kans. Acad. Sci. Trans., 43:433-456, 1940. This appears to be the first published use of this technical name in Kansas lists *coupled with the common name of Sitka crossbill,* since Griscom's revision of the species in 1937. Note (above) that prior to 1931, the A. O. U. Check List used this technical name for what is now termed the Newfoundland Crossbill.

Loxia cirvirostra benti Griscom. Rocky Mountain crossbill. Long, W. S., Check list of Kansas birds. Kans. Acad. Sci. Trans., 43:433-456, 1940. This appears to be the first published use of the name for a Kansas bird since Griscom established the term in 1937.[6] Griscom lists 41 Kansas skins dated between 1885 and 1931, specimens formerly listed as *L. c. minor* or as *L. c. bendirei.* Hence the *name* but not the *form* is of recent acquisition.

Passerculus sandwichensis nevadensis Grinnell. Nevada savannah sparrow. Long, W. S., Three subspecies of birds not previously reported from Kansas. Condor, 37(1):39, 1935. "A female . . . proves to be of this race."

Ammodramus savannarum perpallidus (Coues). Western grasshopper sparrow. Bunker, C. D., Birds of Kansas. Kans. Univ. Sci. Bul., 7(5):137-158, 1913. "New to the list" under the name of *A. s. bimaculatus* (Swainson).

Ammodramus bairdi (Audubon). Baird's sparrow. Long, W. S., Check list of Kansas birds. Kans. Acad. Sci. Trans., 43:433-456, 1940. Wetmore wrote in The Auk, 37:457-458, 1920, that the an-

[6]Griscom, Ludlow, A monographic study of the red crossbill. Boston Soc. Nat. Hist. Proc., 41:77-209, 1937.

nouncement by Logan Evans in The Oölogist, 24(Aug.) :124, 1907, was based on an error.

Pooecetes gramineus confinis Baird. Western vesper sparrow. Bunker, C. D., Birds of Kansas. Kans. Univ. Sci. Bul., 7(5) :137-158, 1913. "New to the list."

Chondestes grammacus strigatus Swainson. Western lark sparrow. Bunker, C. D., Birds of Kansas. Kans. Univ. Sci. Bul., 7(5) : 137-158, 1913. "New to the list."

Junco oreganus montanus Ridgway. Montana junco. Bunker, C. D., Birds of Kansas. Kans. Univ. Sci. Bul., 7(5) :137-158, 1913. Apparently recorded here for the first time, under the name of *Junco hyemalis montanus.*

Junco mearnsi Ridgway. Pink-sided junco. Long, W. S., Observations on the November birds of Western Kansas. Kans. Univ. Sci. Bul., 22:225-248, 1935. "This is the first record for Kansas."

Spizella passerina arizonae Coues. Western chipping sparrow. Long, W. S., Check list of Kansas Birds. Kans. Acad. Sci. Trans., 43 :433-456, 1940. Possibly this reference first mentions this race in Kansas in published form. Long's unpublished Master's thesis, Birds in Kansas, Kansas University Library, 1935, tells of an immature form taken in Western Kansas in October.

Spizella pusilla arenacea Chadbourne. Western field sparrow. Bunker, C. D., Birds in Kansas. Kans. Univ. Sci. Bul., 7(5) :137-158, 1913. "This specimen is in Dr. Snow's collection, but is not listed in his catalogue."

Melospiza melodia beata Bangs. Mississippi song sparrow. Long, W. S., Observations on the November birds of Western Kansas. Kans. Univ. Sci. Bul., 22 :225-248, 1935. ". . . one specimen . . . referred to this subspecies."

Melospiza melodia juddi Bishop. Dakota song sparrow. Bunker, C. D., Birds of Kansas. Kans. Univ. Sci. Bul., 7(5) :137-158, 1913. "Several collected in the fall of 1911 and 1912."

Melospiza melodia fallax (Baird). Mountain song sparrow. Long, W. S., Observations on the November birds of Western Kansas. Kans. Univ. Sci. Bul., 22:225-248, 1935. "Specimens . . . referred to this subspecies but are not quite typical."

Calcarius lapponicus alascensis Ridgway. Alaska longspur. Bunker, C. D., Birds of Kansas. Kans. Univ. Sci. Bul., 7(5) :137-158, 1913. "Reported in the A. O. U. check list as wintering in Western Kansas. Seven birds of this species [*sic*] were collected in December of 1908. . ."

The Effect of Various Condensing Agents and Inert Solvents in the Production of DDT

THOMAS T. CASTONGUAY and RICHARD L. FERM
Chemical Engineering Department, University of Kansas.

At the present time almost all DDT, 1,1,1-trichloro-2,2-bis (p-chlorophenyl) ethane, produced commercially is made by a process based on the classic and original synthesis of Zeidler.[4] This method consists of condensing chloral or chloral hydrate with chlorobenzene through the action of concentrated sulfuric acid or oleum. Several isomers are possible. According to Gunther,[2] technical DDT produced by the Brothman continuous process contains 70% of the p,p′-isomer, 18% of the o,p′-isomer, and 6% of the o,o′-isomer, the balance being ash, volatile, and unidentified material.

Little mention has been made in the literature of new methods of synthesizing DDT. A student at the Fresno State College[1] is said to have used zinc chloride in place of sulfuric acid as a condensing agent, but this has not yet been confirmed by other reports. Rueggeberg and Torrans[3] have condensed chloral hydrate and chlorobenzene through the action of chlorosulfonic acid to produce a 77% yield of DDT.

In order to obtain satisfactory yields of DDT by the condensation of chloral with chlorobenzene through the action of sulfuric acid, a large excess of acid and chlorobenzene are necessary. The object of this paper is to investigate the use of other condensing agents and the use of inert solvents. Zinc chloride, thionyl chloride, sulfuryl chloride, phosphoric acid, and phosphorus pentoxide were tried as condensing agents. Inert solvents such as carbon tetrachloride, chloroform, carbon disulfide, and skelly solvent were used as solvents for the DDT during its preparation using sulfuric acid as a condensing agent.

Condensing Agents

The following experiments were made to study the effect of substituting various condensing agents for sulfuric acid in the synthesis of DDT. In each case 14.7 grams (0.10 mole) of chloral, and 25.2 grams (0.22 mole) of chlorobenzene were placed in a 500 ml. three-necked flask equipped with a mercury-seal stirrer and a water cooled reflux condenser. The condensing agent was then added, and the reaction mixture stirred and heated on a steam bath at about

89° C. for 2 hours. At the end of that time the reaction mixture was allowed to cool to room temperature, was poured into distilled water, and set aside to settle until the resulting emulsion had cleared. The product, which was an oily layer in each case, was separated and steam distilled. The results are tabulated in Table I. None of the condensing agents gave any DDT.

TABLE 1.—*Effect of Various Condensing Agents on the Synthesis of DDT.*

Exp. No.	Amount of Condensing Agent	Nature of Final Product
1.	Fused zinc chloride 13.6 grams (0.100 mole).	No solid residue. 22 ml. water insoluble oil recovered.
2.	Thionyl chloride 25.2 grams (0.225 mole)	No solid residue. 19 ml. water insoluble oil recovered.
3.	Sulfuryl chloride 9.5 grams (0.07 mole)	No solid residue. 21 ml. water insoluble oil recovered.
4.	100% phosphoric acid 138.3 grams (1.411 mole)	0.6 grams of solid, M.P. 115-121° C. 20 ml. water insoluble oil recovered.
5.	Phosphorus pentoxide 14.2 grams (0.100 mole)	No solid residue. 21.5 ml. water insoluble oil recovered.

INERT SOLVENTS

Carbon disulfide, chloroform, carbon tetrachloride, and skelly solvent (B.P. 89 to 95° C. at 738 mm.) were tried as solvents for the DDT in its preparation by the condensation of chloral and chlorobenzene using sulfuric acid as a catalyst. All reactions were carried out in the following manner; 14.7 grams (0.1 mole) of chloral, 25.2 grams (0.2 mole) of chlorobenzene, 50.0 grams of 100% sulfuric acid, 33.3 grams of fuming sulfuric acid containing 24.0% free SO_3, and the desired solvent were placed in a 500 ml. three-necked flask equipped with a mercury-seal stirrer and a water-cooled reflux condenser. The reaction mixture was cooled in an ice bath to 0° C., the stirrer started and the reaction mixture stirred at 0° C. for 10 minutes. The ice bath was then removed and the stirring continued for 20 minutes more. At the end of this time the reaction mixture was at room temperature and it was placed in a steam bath, and the mixture heated and stirred at the boiling point of the solvent for 2 hours. At the end of this time the reaction mixture was allowed to cool to room temperature, was poured into crushed ice, and allowed to stand overnight. The mixture was then filtered and the residue freed from excess chlorobenzene by steam distillation. The solid residue was dried at 85° C. for 2 hours, weighed and designated as crude DDT. The crude products of exps. 6, 7, and 8 on re-

crystallization from 95% ethyl alcohol gave white crystalline solids

TABLE 2.—*Effect of Inert Solvents on Yield of Crude DDT.*

Exp. No.	Solvent Used	Color and State Of Final Product	Wt. of Final Product	% Yield DDT Solids
6.	30 ml. CS_2	Grey-white solid M.P. 85-91° C.	14.68 g.	41.4
7.	30 ml. CCl_4	Semi-plastic brown solid	17.39 g.	49.1
8.	28 ml. $CHCl_3$	Grey-white solid M.P. 86-91° C.	19.00 g.	53.59
9.	30 ml. skelly solvent	Black gum	21.9 g.	61.7*

*The last yield contained a large amount of tar in addition to any DDT which may have been formed, and was absolutely unsatisfactory.

melting at 105-106° C. A second recrystallization raised the melting point to 107-108° C. The results are shown in Table II. Skelly solvent was unsatisfactory because of the large amount of tar present in the product. Carbon disulfide, carbon tetrachloride and chloroform all gave low yields of DDT.

LITERATURE CITED

(1) ANONYMOUS, *Fresno Bee*, March 31 (1944).
(2) GUNTHER, F. A., *J. Chem. Ed.* 22, 238-42 (1945).
(3) RUEGGEBERG, W. H. C., and TORRANS, D. J., *Ind. End. Chem.* 38, 211-14 (1946).
(4) ZEIDLER, O., *Ber.* 7, 1180-1 (1874).

Where Theory and Practice Should Meet

FRANCIS GREGORY
Wyandotte High School, Kansas City.

Theory and practice *do* meet when the pupil completes his schooling and becomes an employee. They *should* meet much earlier. Close cooperation between those responsible for what is included in schooling and those responsible for hiring and placing workers can place this meeting where it should be. Responsible employers should be eager to write the specifications for new employees they will need in the future just as carefully as they now write the specifications for a new tool, a new assembly line, or a new building. Responsible educators should be just as eager to analyze these specifications, and just as capable of offering suggestions, as the engineer or the technical expert is to analyze the specifications for new material additions to plants.

New and wonderful machines and processes have been designed to meet the specialized needs of industry and business. When one of the major airlines needed a new plane for its expanding world routes it did not just shop for the best plane on the market. It cooperated with professional, technical, and business experts of a factory and together they designed and produced an entirely new plane that far outstripped anything that was on the market when the need was first recognized.

Does it not follow that as employers recognize the need for new personnel they should go to the professional, technical, and business experts in the schools and together with them design and produce a type of training that fits the need far better than the best training that now exists? Why shop around for what the market has to offer in the way of personnel? Why not draw the blueprint and write the specifications cooperatively and then charge the schools with the responsibility of turning out the best product possible with the best material that is available? Just as manufacturers have had to give up their reluctance to depart from what has become familiar to them, so will educators have to be ready to investigate, try out, and evaluate new processes in schooling, and to adapt those that prove adequate to the demands of the times.

As businessmen and industrialists on the one hand and educators and psychologists on the other hand enter this sphere of cooperation, they will face problems for which solutions are not easily found. Some of these problems are already controversial and must

be approached from an objective and scientific point of view. Educators must recognize the right of employers to write specifications, and employers must recognize that educators, as human engineers, are working with a raw material that is affected differently by exterior pressures, tensions, and forces than is the raw material with which the engineer, the scientist, and the manufacturer work.

Theory and practice should first meet in determining the kind and amount of basic training that all employees should receive. Some agreement must be reached as to the importance of manual and physical dexterity in the training that every child should have. Some common understanding regarding the place of academic training in this basic or general education for everyone should be reached. Should each individual be required to meet fixed minimum standards in reading, spelling, writing, speech, arithmetic? Theory and practice should reach a common agreement concerning social requirements of this core of training which every individual should receive. How much time and tax money should schools spend in developing poise, ability to get along with others, in developing initiative and clear thinking? Should this core of training include acquaintance with tools, appreciation of quality of materials, knowledge of values, mental and manual accuracy? *Can* these qualities be developed through training in school?

Theory and practice should meet and establish some definite criteria for enabling the individual to decide whether or not he should receive more training than the core provides. At this point theory and practice should not only meet but should work together in helping individuals make life decisions. Each individual who goes beyond the core training has to decide into which of the thousands of occupational possibilities he should direct his specialized training. Education and business and industry can reach a new high point in cooperation if they combine their efforts in gathering accurate occupational information and presenting it logically and interestingly to youth. Not so many years ago youth chose its individual occupations from the several commonly known ones that were available. Today youth is faced with a complexity of choices. Wisdom in choosing can come only with more accurate vocational information than most young people have at their command today.

Theory and practice should meet on the common ground of records. Employers make only nominal use of school records as they now exist. Records which contain objective information and a summary of subjective appraisals by qualified professional people are

useful in selecting and wisely placing personnel. There is some agreement among employers that records containing the following information would be useful: academic grades, attendance, mental ability, special aptitudes, honesty of purpose, vitality, initiative, loyalty, quality of character, adaptability to change, ability to get along with others, participation in activities, and work aptitude. In Kansas, as in several other states, there is a statewide aptitude testing program in the developmental stage. As this program grows, statewide norms will be developed which will give employers a rating of individual aptitudes. Under this system the potential abilities of individual employees may be compared with the average of thousands of others in the state. In some schools this kind of testing is at present more highly developed than it is in any but the most progressive employment offices. School people, including psychologists, and employers as well, must be alert to possibilities for improving the selection of tests and of revising their content so as to make them fit the changing needs of business and industry.

On the other side of the picture, educators may make profitable use of the personnel records of industry when they are available. Honest appraisal by capable employers of the product of the schools offers to educators a means of evaluating their work and hence a means of correcting weaknesses in the educative process. A study of such records offers educators a valuable means of continuous curriculum adjustment. When theory and practice meet on the common ground of records, perhaps there will be developed a form of record keeping readily interchangable between schools and emplyment offices.

Theory and practice should meet in the field of work experience. There are good and valuable lessons which can be learned more readily in employment situations than in school or home. The individual combines theory and practice in a well-chosen work experience program, where the learning he acquires in school can be put into use on the job. Coordinating the school experience and the job experience so that each supplements the other needs to be developed far beyond anything that exists in this line at the present time. Some questions yet to be answered are: Should young workers be shifted from job to job in order to get more varied experience? How much can the employer afford to pay such learners? Can capable and understanding supervisory help be made available by the employer? Do employers have a moral obligation to society to provide work experience opportunities? Is there danger of individuals getting into

blind alley jobs through work experience program placement? How much on-the-job supervision is the school obligated, entitled, and equipped to exercise?

Theory and practice must meet in the field of labor relations if our present form of government is to continue to exist. The present labor and industrial unrest is due in part to the fact that practice deviates too widely from theory. The attempt must be made, and education must assume its share of the burden, to level such barriers as greed, lust for power, assumption of privilege, conspicuous consumption of wealth, and prejudice. Perhaps as intellectual leadership continues to replace brass knuckle leadership on the part of both labor and management, the meeting place will be reached. Certainly, schools, labor, and industry have all neglected to provide young citizens with information about labor relations and problems. The result is that most of them have a mass of prejudice rather than intelligent informed opinion about labor problems.

Summing up, here are five of the problems requiring a combination of theory and practice for their solution: What kind and how much general education should all people receive? How should youth decide whether to take advanced training and what kind of training? How can school and employment records be improved and coordinated? Should work experience be extended to a greater number of pupils, and if so, to whom? What can be done to increase the general level of information concerning labor and industrial relations?

Psychologists, ,businessmen, industrialists, educators, all can work together for the solution of these problems and thus release the power of the world's greatest natural resource, that is, human capacity and human will to work and produce.

The Chemical Composition of Forbs in the Native Pastures at Hays, Kansas.*

NOEL R. RUNYON
Phillipsburg, Kansas.

Cattle are often seen grazing weeds and perennial herbaceous plants (forbs) in their search for food. This habit, if it may be called a habit, is followed where grass forage is plentiful as well as where it is not so plentiful. The purpose of this research was to determine the chemical composition of these forbs and to determine the contribution of each one to the diet of the cattle.

Time and Method of Sampling

The samples for this study were collected in the summer and fall of 1943 at the time of the greatest apparent use by the cattle. Only those portions of the plant taken by the cattle were analyzed. Samples were also collected of a few plants that were noticeably avoided for the sake of comparison. A few samples of the short grasses were collected as a correlation check against analyses of grasses made from previous collections in the same area. (Runyon, 1943). Composite samples collected from a wide range of sites were used to minimize the error caused by the limited number of samples.

Environmental Conditions

The samples of these forbs were collected in the native pastures located a few miles west of Hays, Kansas. The area is quite rolling with some rather deep ravines. The carbonate layer is quite shallow and frequently the native limestone appears on the surface along the slopes of the hills. (Albertson, 1937). The spring and summer months were exceptionally dry until the first week in September.

Methods of Analysis

The procedures for these analyses were taken from the Association of Official Agricultural Chemists (1940) with the exception of the phosphorus procedure which was taken from Talbot's Quantitative Chemical Analysis (Hamilton and Simpson, 1937). Nitrogen-free-extract (N. F. E.) was determined by subtracting the percentages of ash, protein, fiber, and fat from 100 per cent. Three determinations were made of each sample for each constituent sought and the three results were averaged together.

• Transactions Kansas Academy of Science, Vol. 49, No. 4, 1947.
*These studies were aided by a grant from The Kansas Academy of Science.

Results

The food value of these forbs, as shown by these analyses, is quite similar to the blue grama in some instances and in others very dissimilar (Runyon, 1943). All of the forbs that were analyzed had a high calcium and phosphorus content. (Table I). There was appreciable variation in the amount of total fats and total crude protein in the different forbs collected. The percentage of dry matter was fairly uniform in the various forbs that were analyzed.

Discussion of Results

The results of these analyses failed to reveal any significant differences in the composition of those forbs that were being consumed and those not being consumed. For example, consider the analyses of Solidago rigida. The first sample was collected at the time the cattle were grazing that particular species and the later sample was collected after they had stopped grazing on it. The first sample consisted of the flower buds and upper leaves, the later of mature flowers and upper leaves. The greatest apparent change occurred in the percentages of dry matter, total ash, and fiber. The dry matter and total ash increased while the fiber decreased in percentage in the later sample.

Table I.—*Per Cent Chemical Composition of the Forbs Utilized and Not Utilized by the Cattle, Hays, Kansas.*

Name of Plant	Dry Matter	Ash	Calcium	Phosphorus	Fat	Fiber	Crude Protein	Nitrogen-Free Extract
Plants Utilized by Cattle								
Aster multiflorus (Many flowered aster)	49.0	7.9	0.24	0.43	14.3	22.2	9.1	45.9
Amorpha canescens (Lead plant)	55.7	10.4	2.8	0.92	8.5	21.5	8.2	47.7
Petalostemon purpureus (Purple prairie clover)	44.4	8.1	2.8	0.43	8.2	26.2	6.6	47.7
Scutellaria resinosa (Britton's skull cap)	41.7	11.0	1.2	0.45	10.2	19.5	4.2	53.4
Solidago glaberrima (Missouri goldenrod)	46.7	7.1	1.0	0.33	17.2	9.6	10.4	54.6
Solidago mollis (Velvety goldenrod)	45.2	8.3	1.1	0.70	13.8	12.7	8.8	54.6
Solidago rigida (Stiff leafed goldenrod)-Collected August 11	25.6	5.9	1.3	0.52	11.6	15.5	6.9	58.3
Plants Not Utilized by Cattle								
Gutierrezia sarothrae (Broom snakeweed)	74.2	8.4	0.70	0.60	14.0	19.9	7.7	48.7
Malvastrum coccineum (Red false mallow)	50.2	11.6	3.5	0.42	14.9	12.2	7.8	49.6
Solidago rigida (Stiff leafed goldenrod) Collected September 17	38.6	7.9	1.12	0.48	10.5	9.9	7.8	62.3

Conclusions

The greatest apparent contribution of the forbs to the cattle diet seems to come from their high percentage of calcium and phosphorus. The quantities of crude protein, fiber, and dry matter were not significantly different from those found in blue grama from the same general area (Runyon, 1943).

Bibliography

Albertson, F. W. 1937. Ecology of the mixed prairie in West Central Kansas. Ecological Monograph 7:491-2.

Association of Official Agricultural Chemists, Fifth Edition. 1940. Association of Official Agricultural Chemists. Washington, D. C.

Runyon, Noel R. 1943. The effect of season of growth and clipping on the chemical composition of blue grama (Bouteloua gracilis) at Hays, Kansas. Transactions Kansas Academy of Science, Vol. 46. 1943.

The Nutria, a South American Rodent, in Kansas

DONALD F. HOFFMEISTER and CHARLES D. KENNEDY
University of Kansas, Museum of Natural History, Lawrence.

A feral nutria, *Myocastor coypus,* was captured in the fall of 1945 in central Kansas. The animal was cornered by a dog near a pond on the O. A. Dunn farm, along Peace Creek, twenty-four miles west and two miles north of Hutchinson, in Reno County. The nutria, a semiaquatic, South American rodent, which resembles our native muskrat in size and habits, has been reared in recent years on fur farms in the United States. Although nutrias have occasionally escaped from such fur farms and become established in the wild, we know of no fur farms with captive nutria or other fur bearers in this part of Kansas, nor of nutria elsewhere in the state. Feral nutrias have been recorded elsewhere in the United States, as in Montana (Jellison, Jour. Mamm., 26:432, 1945), Washington and Oregon (Larrison, Murrelet, 24:3, 1943), Louisiana (Lowery, Occas. Papers Mus. Zool., La. State Univ., no. 13:248, 1943), and New Mexico (Sooter, Jour. Mamm., 24:503, 1943). In France, the nutria escaped from fur farms after World War I and now has become established in the wild over much of that country (see Bourdelle, Jour. Mamm., 20:288, 1939). Laurie (Jour. Animal Ecol., 15:22-34, 1946) gives a full account of the nutrias in England, many of which escaped from fur farms abandoned at the start of World

FIG. 1.—Live nutrias in the National Zoological Park, Washington, D. C. Photographed by Joao Moojen.

War II, and reviews some of the damage the colonies, now established in the wild, are doing.

After the capture of the nutria in September, 1945, by the Dunns, it was kept in captivity by them until its death in January, 1946. Although vicious when captured, it soon became docile and made a good pet. In captivity, it ate with relish raw carrots, sweet and Irish potatoes, cabbage, onions, ripe and green tomatoes, and such grains as corn and milo maize. Although the nutria is known to be able to live in regions where the winters are cold, the individual taken in Kansas, while housed in an open garage, had the distal end of its tail so completely frozen in a sub-zero storm that the terminal half of the tail was lost.

The accompanying photograph (figure 1) shows how the nutria differs from its distant cousins, the muskrat and beaver. The naked, round tail readily distinguishes the nutria from any North American water-dwelling fur bearers. The webbed hind feet and small ears are specializations for aquatic life. The commercial value of the fur of the nutria in the United States is, at present, slight.

The nutria, because of its food proclivities and its adaptability, may become a pest around gardens and vegetable farms. Here, in Kansas, it probably would compete with the muskrat in establishing itself and might succeed in usurping many of the ecologic niches previously occupied by muskrats. Since the fur of the nutria is currently less valuable than that of the muskrat and since the feral nutria might become an agricultural pest, it seems wise, if possible, to prevent the establishment of the nutria in Kansas. To prevent establishment through escape from fur farms, it would be advisable for the appropriate state authority to inspect now and in the future such farms as raise nutria to insure that they are as securely inclosed as is possible. It may even be advisable, for the welfare of the state, that authority should be arranged to export or destroy any nutrias found and to prohibit possession of live nutrias in Kansas in the future.

Selected Records of Reptiles and Amphibians From Southeastern Kansas

HENRY H. HALL and HOBART M. SMITH*
Kansas State Teachers College, Pittsburg,† and *Museum of Natural History, University of Kansas, Lawrence.

Material accumulated in the Museum of Pittsburg State Teachers College by the senior author, from Labette, Crawford and Cherokee counties, includes three species of which specimens seem not to have been recorded previously from within the borders of Kansas. Records of these three species and certain other noteworthy occurrences are published here as a contribution to our knowledge of the herpetological fauna of the state. The locality data are supplied by Hall and the taxonomic data by Smith. All specimens, originally identified by Hall, have, with few exceptions, been checked by Smith, and certain specimens have been studied in detail. The specimen of *Opheodrys vernalis blanchardi* has not been seen by Smith. Unless otherwise specified, catalogue numbers are those of the Museum of Pittsburg State Teachers College.

Necturus maculosus maculosus (Rafinesque)

Common in several small streams within three or four miles of Pittsburg, Crawford County.

Cryptobranchus alleganiensis (Daudin)

An adult female (No. 586) was taken from the Neosho River in Labette County, due west of McCune, Crawford Co., and a half grown individual (No. 4562) is from a small tributary of Spring River, one mile north of Riverton, Cherokee Co. The measurements are, respectively: snout to vent, 275 mm., 185 mm.; length of tail, 150 mm., 85 mm.; depth of tail, 52 mm., 27 mm.

This record of occurrence extends the known range 200 miles westward, including for the first time the Arkansas River Valley.

In adult: large, diffuse dark spots present on dorsal surface of body and sides of tail; dusky color of central gular region gradually merging with dark color of labial region; gular and labial spots not apparent; two folds on posterior borders of thighs; prevomerine teeth 19-22; greatest diameter of gill slit exactly half of internarial distance.

The smaller specimen has on the dorsal surface small, dark

Transactions Kansas Academy of Science, Vol. 49, No. 4, 1947.

†The death of Dr. Hall occurred on Jan. 2, 1946 as reported in these *Transactions* for March, 1946.

spots, the diameter of which do not exceed half the internarial distance, no distinct spots on the tail (specimen somewhat shriveled and pattern thus not clearly discernible), folds on body like those on the larger specimen, prevomerine teeth 16-17, and diameter of gill slit slightly less than half of internarial distance.

These specimens have been compared directly with a large, typical *C. bishopi* (Univ. Kans. No. 16143) from Greene Springs, Vernon Co., Missouri. They do not have the curious, distinct spotting of that species, nor do they have the distinctive small gill slits. Despite the greater proximity of the localities from which the Kansas specimens were taken to the area where *C. bishopi* occurs than to areas where *C. alleganiensis* has been recorded, the Kansas specimens cannot be identified with *C. bishopi.*

Unfortunately adequate comparative material of *C. alleganiensis* is lacking. The single specimen available (Univ. Kans. No. 19742), from Mammoth Cave, Edmonson Co., Kentucky, is discolored and distorted. No differences that could not be attributed to preservation are apparent upon comparison with the Kansas specimens however. Comparisons of the latter with published descriptions reveal no peculiarities. We therefore tentatively regard the specimens as typical *C. alleganiensis.*

Ambystoma maculatum (Shaw)

A fine adult made was taken in the basement of a house one mile north of Pittsburg, Crawford Co., Kansas. It is the second specimen known from the state and the only one with specific locality data.

Snout to anterior margin of vent, 77 mm.; tail 77 mm.; 12-13 costal grooves; dusky above and below, lighter below; a dorsolateral row of nine round light spots, the first row in contact with supraorbital area; no markings whatever on ventral surface.

Ambystoma texanum (Matthes)

First Cow Creek, one mile west of Pittsburg, Crawford Co. (No. 1256); and 9th Street in Pittsburg, Crawford Co. (now in Univ. Kans. Mus. Nat. Hist.)

Bufo americanus americanus (Holbrook)

Pittsburg, Crawford Co. (No. 732). The absence of any representative of *Bufo woodhousii* in the collections from this area is of considerable interest. If present, the subspecies should be *B. w. fowleri,* a race not yet definitely recorded from the state.

Hyla versicolor versicolor (Le Conte)

Mt. Olive Cemetery, Pittsburg, Crawford Co. (No. 7489).

Rana areolata circulosa Rice

Fairview Cemetery, Pittsburg, Crawford Co. (No. 7489).

Rana catesbeiana Shaw

College Lake, campus of Pittsburg State Teachers College, Pittsburg, Crawford Co. (No. 1414).

Rana pipiens berlandieri Baird

College Lake, campus of Pittsburg State Teachers College, Pittsburg, Crawford Co. (No. 1415).

Sternotherus odoratus (Latreille)

Seven miles south of Pittsburg, near Highway 69, Crawford Co. (No. 3251).

Kinosternon flavescens flavescens (Agassiz)

Turkey Creek, one-half mile east of Mineral, Cherokee Co. (No. 6801) ; Pittsburg, Crawford Co.

Macrochelys temminckii (Troost)

No preserved specimen of this species from Kansas is available, but the senior author has seen an individual weighing 402 pounds taken about 1937 from the Neosho River in Cherokee Co., Kansas, a half mile east of Chetopa, Labette Co. It became the property of a man who for small fees exhibited it widely over the state. For a time it was at the State Fish Hatchery in Pratt. One other was taken at the same place but its history is unknown. A third specimen was dredged in relatively recent years from a canal off the Arkansas River in Wichita, Sedgwick County, Kansas, and according to Dr. C. W. Hibbard a picture of it was published in a Wichita paper. Further evidence of the occurrence in Kansas of this species is contained in Victor Housholder's unpublished dissertation (1915): "Mr. D. M. Bliss of Columbus, Cherokee County, Kansas, has in his possession two shells of this turtle, which he very kindly furnished me for examination. The larger specimen measures (carapace) 22 in. in length by 21 in. in height, and weighed 105 lbs. when caught. The other specimen measures 16 in. by 16 in. and weighed 65 lbs. when captured. The larger specimen was captured by Andrew Jarrett at Rocky Ford on the Neosho River in 1897, and the smaller one by Capt. Price at Baxter Springs on the Spring River in 1895 . . . I have personally taken this turtle at three different localities in the state; one was taken in the Neosho River in the summer of

1911 just below Neosho Park (Parsons); a second was taken in the Walnut River at Augusta in 1912; and a third in the Cottonwood River at Florence during the same summer."

Although no subsequent notice has been taken of it, this species was actually recorded from Kansas many years ago, in 1886, by Cragin (1886:212), who writes: "Prof. Snow adds to the Kansas fauna the Mississippi Snapper (*Mac. lacertina*), in the following note upon the largest turtle known to have been captured in the State: "Captured by Wm. Butler, May, 1885, two miles above Erie, in the Neosho River. Wt. 59 lbs. Length 47* in. Length of carapace 20 in., breadth of same 16 in., circumference of head 18 in.,—of base of neck 17½ in.,—of narrowest part of neck 15 in."

"By his mention of its size we were reminded of the skull in Washburn cabinet, presented by Dr. Newlon, of a 34 lb. turtle taken from the Neosho at Oswego, a year since . . . The director of the Survey [Cragin] has now studied the specimen, which is *Macrochelys lacertina,* beyond a doubt."

The occurrence of this species as far north as southern Kansas in large tributaries of the Mississippi River such as the Arkansas River and its larger feeders including the Cottonwood, Neosho, Spring and Walnut rivers, is not to be considered extraordinary in view of its known habit of upstream migration three miles per year (see Pope, 1939:68) and in view of the verified occurrence of the species elsewhere as far north as central Illinois.

Chelydra serpentina serpentina (Linnaeus)

Pittsburg, Crawford Co. (No. 942).

Graptemys geographica (Le Sueur)

Crawford Co. State Park, three miles north of Pittsburg (No. 286).

Graptemys pseudogeographica pseudogeographica (Gray)

Columbus, Cherokee Co., and Crawford Co. State Park, three miles north of Pittsburg (No. 477).

Chrysemys picta bellii (Gray)

Mineral Lake, Cherokee Co., and Pittsburg, Crawford Co. (No. 802).

Pseudemys scripta elegans (Wied)

Four miles south of Columbus, Cherokee Co., and Crawford Co. State Park, 3 miles north of Pittsburg, Crawford Co. (No. 806).

*Printed 27½, but corrected in ink, apparently by Cragin, as indicated by various other corrections throughout the volume.

Amyda spinifera spinifera (Le Sueur)

Tributary of Spring River 1 mile north of Riverton, Cherokee Co. (No. 1532); Pittsburg, Crawford Co.

Crotaphytus collaris collaris (Say)

One mile north of Columbus, Cherokee Co.; six miles north of Pittsburg, on Highway 69, Crawford Co. (No. 992).

Sceloporus undulatus hyacinthinus (Green)

Crawford Co. State Park, three miles north of Pittsburg (No. 698).

Phrynosoma cornutum (Harlan)

Columbus, Cherokee Co. (No. 699); Pittsburg, Crawford Co.

Ophisaurus ventralis (Linnaeus)

Pittsburg, Crawford Co. (No. 391).

Cnemidophorus sexlineatus (Linnaeus)

Crawford Co. State Park, three miles north of Pittsburg (No. 707).

Leiolopisma laterale (Say)

Pittsburg, Crawford Co. (No. 1347).

Eumeces fasciatus (Linnaeus)

Farlington Lake, seven miles north of Girard, Crawford Co. (No. 846).

Eumeces obsoletus (Baird and Girard)

Farlington Lake, seven miles north of Girard, Crawford Co. (No. 847).

Diadophis punctatus arnyi (Kennicott)

Second Cow Creek, three miles east of Pittsburg, Crawford Co. (No. 1314).

Heterodon contortrix contortrix (Linnaeus)

Two miles north of Weir, Cherokee Co.; Crawford Co. State Park, three miles north of Pittsburg (No. 245).

Heterodon nasicus nasicus (Baird and Girard)

One mile east of Arma (No. 292), and Pittsburg, Crawford Co.

Opheodrys aestivus (Linnaeus)

First Cow Creek, one mile west of Pittsburg, Crawford Co. (No. 369).

Opheodrys vernalis blanchardi Grobman

Six miles west of Pittsburg, Crawford Co. (No. 393).

Coluber constrictor flaviventris (Say)

Two miles south of Columbus, Cherokee Co. (No. 173); Pittsburg, Crawford Co.

Elaphe obsoleta obsoleta (Say)

Scammon, Cherokee Co. (No. 199); three miles south of Pittsburg, Crawford Co.

Pituophis catenifer sayi (Schlegel)

Lowell, Cherokee Co. (No. 138); Pittsburg, Crawford Co.

Lampropeltis calligaster calligaster (Harlan)

Two miles east of Weir, Cherokee Co. (No. 302); Mt. Olive Cemetery, Pittsburg, Crawford Co.

Lampropeltis getulus holbrooki Stejneger

Columbus, Cherokee Co. (No. 349); Pittsburg, Crawford Co.

Lampropeltis triangulum syspila (Cope)

One mile east of Pittsburg, Crawford Co. (No. 362).

Sonora episcopa (Kennicott)

Seven miles west of Pittsburg, Crawford Co. (No. 11021).

Natrix erythrogaster transversa (Hallowell)

Pittsburg, Crawford Co. (No. 1464).

Natrix grahamii (Baird and Girard)

Columbus, Cherokee Co.; Crawford Co. State Park, three miles north of Pittsburg (No. 1463).

Natrix rhombifera rhombifera (Hallowell)

Pittsburg, Crawford Co. (No. 1462).

Natrix sipedon sipedon (Linnaeus)

Pittsburg, Crawford Co. (No. 1461).

Storeria dekayi texana Trapido

Croweburg, nine miles north of Pittsburg, Crawford Co. (No. 11022).

Haldea striatula (Linnaeus)

Second Cow Creek, six miles southeast of Pittsburg, Highway 54, Crawford Co. (two specimens).

Both specimens are males; one measures 233 mm. in total and 45 mm. in tail length, the other 185 mm. and 35 mm., respectively. Scale counts are, respectively: scale rows 17-17-17, 17-17-17; ventrals 128, 125; caudals 43, 44; supralabials 5-5, 5-4 (1st and 2nd fused); infralabials 6-6, 6-6; temporals 1-1, 1-1; preoculars 0-0, 0-0; postoculars 1-1, 1-1; internasals 1, 2 (in the latter specimen the

suture between the two scales is asymmetrically placed, and the left scale is considerably larger than the right).

Thamnophis sauritus proximus (Say)

Columbus, Cherokee Co.; Crawford Co. State Park, three miles north of Pittsburg (No. 761).

Thamnophis sirtalis parietalis (Say)

Lincoln Park, Pittsburg, Crawford Co. (No. 762).

Tantilla gracilis Baird and Girard

Radley, Crawford Co. (No. 4612).

Agkistrodon mokeson mokeson (Daudin)

Farlington Lake, seven miles north of Girard, Crawford Co. (No. 7480).

Agkistrodon piscivorus leucostoma (Troost)

A specimen of this race was found in the Neosho River in Cherokee County, due east of Chetopa, Labette Co. It was taken in 1937 in the period of floods that caused havoc generally throughout central United States. When the snake was obtained water was backing up in the river.

So far as we know this is the first specimen to have been found within the actual boundaries of the state. However, as long ago as 1904 Branson (1904:419) suggested that it might be a resident of southeastern Kansas. It has been recorded from several localities near Kansas in Oklahoma and Arkansas (Gloyd and Conant, 1943: 175, map 2), and the senior author has captured a specimen three-quarters of a mile east of the Kansas border on the Spring River in Jasper Co., Missouri. The latter specimen, like the first, is preserved in the collection of the Pittsburg State Teachers College. It may be of interest that this specimen, too, was taken in a flood period. These reports from localities near Kansas lead us to believe that more than one snake has probably been carried into the state by backwater, and that the species has become established within the boundaries of Kansas.

The snake from Kansas measures 870 mm. in total length, of which the tail comprises 130 mm. It is a male, with 25-23-23-19 scale rows (reduced to 24 rows at the 18th ventral, to 23 at the 20th), 137 ventrals, and 47+ caudals (about 3 to 5 caudals appear to be missing at the very tip of the tail). The loreal is absent. The specimen agrees with the characters of the race as defined by Gloyd and Conant (1943:164-165), although it is unusual in having 23 scale rows around the middle of the body.

Sistrurus catenatus tergeminus (Say)

Lightning Creek, 2 miles west of Girard, Crawford, Co. (No. 1929). Belly relatively light.

Crotalus atrox Baird and Girard

A specimen of this species (No. 5280) obtained six miles west of Pittsburg, Crawford Co., and another one mile north of Weir, Cherokee Co., verify the suspected occurrence of this species within the borders of the state. The first specimen cited is now mounted and on display in the museum of Pittsburg State Teachers College. These localities are approximately 150 miles from the northern boundary of the range of the species as previously outlined, and is surprising for, although the terrain is flat and open, the rainfall is heavier than in most parts of the previously known range of the species. Nevertheless, reports have come to one of us (Hall) of what we regard as the same species from a still more eastern locality, in Greene Co. of southwestern Missouri.

It was suspected that the first specimens from Kansas would come from farther west, in Barber Co., because John R. Breukelman of Emporia State Teachers College obtained three specimens in Woods Co., Oklahoma, three-fourths mile south of the Kansas line south of Aetna, Barber Co., Kansas. Furthermore, ranchers in that area of Kansas recognize the southern species as distinct from the common prairie species and say that both occur there.

Crotalus horridus horridus Linnaeus

Farlington Lake, seven miles north of Girard, Crawford Co. (No. 7291).

Crotalus viridis viridis Rafinesque

A specimen (No. 6583) taken seven miles west of Pittsburg near Fleming, Crawford Co., represents the easternmost locality known for the species.

Literature Cited

Branson, E. B. 1904. The Snakes of Kansas. Univ. Kansas Sci. Bull., 2:353-430, figs. 1-39.

Cragin, F. W. 1886. Miscellaneous notes. Bull. Washburn Lab. Nat. Hist., 1 (7): 212.

Gloyd, Howard K. and Roger Conant. 1943. A synopsis of the American forms of *Agkistrodon* (copperheads and moccasins). Bull. Chicago Acad. Sci., 7 (2): 147-170, figs. 1-16, maps 1-2.

Householder, Victor H. 1916. The lizards and turtles of Kansas with notes upon their distribution and habitats. unpublished dissertation, University of Kansas Library: 1-110, ill.

Pope, Clifford H. 1939. Turtles of the United States and Canada. Knopf, New York. xviii+343+v pp. 99 pls.

Transmitted February 21, 1946.

Why Has the White-Tailed Jack Rabbit (*Lepus townsendii campanius* Hollister) Become Scarce in Kansas?

H. LEO BROWN
Mankato, Kansas

Evidence shows that the white-tailed jack rabbit, once common in most of western Kansas, is now scarce. It is difficult to find in writing what has caused the exodus of this animal so that today it is found only in small numbers in northwestern Kansas. Early settlers have no written records stating the reasons why the white-tailed jack rabbit has become rare. This report furnishes information given by Kansans who have seen the numbers of this animal decline in our state.

A. S. Galler (1940) of Hanston, in Hodgeman County, states, "Conditions of farming changed the white-tails' natural habits of living as the grassland has been plowed under." Edwin Harris (1931), Syracuse, Kansas, reports, "I believe that the breaking up of the prairie land has driven the white-tailed jack rabbits out of the country."

L. D. Morgan (1941) of Goodland, Kansas, says, "Some think the white-tailed jack rabbit went out with the plowing up of the buffalo grass to plant wheat." From Weskan, Kansas, J. E. Owens writes, "The breaking of the prairie caused the white-tails' exit and they do not frequent fields except when the fields are covered with snow."

Ira Scott (1942) of Stockton, Kansas, states, "The white-tailed jack rabbit has gone, like other wild life; as civilization came west, they went west." Harry Kistler (1941) of Syracuse, Kansas, believes "That it is not the white-tailed jack rabbits' nature to domesticate under agricultural conditions as does the black-tailed jack rabbit. They are more wild than the black-tails and seem to prefer country where the ratio of prairie to cultivated land is greater than that which exists in western Kansas today."

Hugh Ward (1941), Hoxie, Kansas, states, "The white-tailed jack rabbit does not like our climate and methods of farming. They have gone west into the more open country and to a cooler climate."

Alfred Stude (1939) says, "The methods of farming have driven

Transactions Kansas Academy of Science, Vol. 49, No. 4, 1947.
*Contribution No. 56, Dept. of Zoology, Fort Hays, Kansas State College.

out the white-tailed jack rabbits. They are strictly prairie lovers and have moved on west and northwest."

J. P. Ruppenthal (1927) wrote in the Wilson *World*, "White-tailed jack rabbits were large and made a good target for the guns. Dogs caught them easily for they couldn't run as fast as the black-tails but could run for a longer distance."

Spencer Hull (1940), Scott City, Kansas, says, "White-tailed jack rabbits became scarce because they were larger and tamer than the black-tails and were more easily killed by hunters."

Dean Carver (1940), Oakley, Kansas, states, "The white-tailed jack habbits were not as fast as coyotes and were tame, therefore coyotes, dogs and hunters got them earlier."

Owen Dubbs (1942) of Ness County, says, "The black-tailed jack rabbits chased out the white-tailed jack rabbits."

The following report comes from George Nellans (1932), Jennings, Kansas: "The white-tailed jack rabbits could not stand the heat like the black-tailed jack rabbits. They had fewer young per litter and fewer litters per year than the black-tailed jack rabbits."

R. D. Dowell (1944), Kanarado, Kansas, states, "The severe winters of the early days may have been the cause of reduced numbers of the white-tailed jack rabbit."

Summary

The change in distribution of the two species of jack rabbits in Kansas was gradual. The changes in environmental conditions when man began to break up the prairie and plant crops, especially wheat, seems to be the most reasonable explanation for the decrease in numbers of the white-tailed jack rabbit. The changing of the open prairie to cultivated land seemed to make conditions more favorable for the black-tailed jack rabbit to adapt itself to the new agricultural environment. This thought was reported by several of the early pioneers of western Kansas.

Bibliography

Black, J. D. 1937. Mammals of Kansas. Thirtieth Biennial Report of the Kansas Board of Agriculture, 1935-1936, pp. 116-217, 36 figs.

Brown, Leo. 1940. The Distribution of the White-tailed Jack Rabbit (*Lepus townsendii campanius* Hollister) in Kansas. Trans. Kan. Acad. Sci. vol. 43, pp. 385-389, 1 fig.

Burnett, W. L. 1926. Jack Rabbits of Eastern Colorado. Colorado Agricultural College Circular No. 52, Fort Collins, Colorado.

Hibbard, Claude W. 1944. A Checklist of Kansas Mammals, 1943. Trans Kans. Acad. Sci. vol. 47, pp. 61-88.

Group Interpretation of Test Results

W. J. MUELLER
St. John's Military School, Salina.

This is a brief report of group test interpretation given to seniors at St. John's Military School during their last semester as a part of their preparation for college entrance. The purpose of the interpretation was to provide the cadets with information and sufficient interpretation to allow them to gain a better understanding of their aptitudes, interests, achievements and personal adjustment in order to permit them to formulate plans to take better advantage of their own abilities in the light of the opportunities their own situations afforded.

The group interpretation was a preliminary to individual conferences held between the cadet and the school counselor. At the conclusion of the group interpretation, each cadet was required to write a personal appraisal and formulate a program of action, incorporating any new facts gained from the tests and the orientation lectures given simultaneously. This self-appraisal formed a basis for the individual interview which followed. The group interpretation presented an opportunity to explain to the cadets various aspects of personality characteristics, vocational interests, academic achievement and academic ability. As the significance of each subtest was interpreted, the individual cadet could compare his rating with that of others.

A battery of thirty-three tests was administered and scores from these were placed on a profile sheet to permit interpretation of scores in terms of percentile rank, standard scale and mental age. The norms, in all cases, were the author's published norms for college freshmen. The score of each cadet was shown by a letter-symbol which that cadet alone knew. Table I presents one such chart (page 458).

1. When interpreting test results to cadets, care was taken to explain the nature and limitations of test scores. Interpretative language was suited to the level of experience and understanding of high school seniors. For instance, we never speak of mental capacity but rather of academic ability. A great deal of stress was laid on the proper academic achievement and academic ability for success in college work. Where remaining retardations were discovered and resolvable, it was recommended that cadets take private tutoring or that the cadet enroll for a "brush-up" course during the summer.

2. One personal audit test suitable for this age level was given and the test results were interpreted. This test gave the cadets a rather generaal appraisal of personality characteristics which we

Standard Scale	3 35	4 4.5	5 55	6 65	7 7.5
Percentile	2 7 15	25	50 75	85 93	98
Mental Maturation (High School)	14 15	16 16.10	17 18	19 20	21
Academic Ability-Power		FM	ERCA L	KON BGHS VP	TD UJ
Academic Ability-Speed		M R E F K L	P A QO NUD V T	BCS H G	J
Reading-Rate	W K	HP GOL M	RQB CTA V	E	SJN
Reading-Comp.	B	EWP MQ	KTG AVR	NOHSL C	J
Vocabulary		MKEL PF NR	ACBT GU H V	D	J
English-Literature		M C	AEBHS LNVKPO QFGTD	R U	J
Mathematics		RLE	O FKCM D	Q A UVB STH PNG	J
Science			O AV M LEHFG RK Q	U P C NBT	DSJ
History-Social Studies		LP MQ	AC N SBVR K F	H QTD U G E	J

TABLE I

felt would be helpful in assisting the cadet in a self-appraisal of the more or less general aspects of his own personality.

3. One emotional maturity and one personality attitude analyzer were administered but the results of these tests were not reported to the cadets. These were used by the counselor during the personal interview to determine the presence of emotional factors of such a character as to warrant referral to the psychologist for further counselling.

4. During the individual interview, the cadet presented to the counselor his own written appraisal of himself, which had been prepared for credit in his English class. The counselor went over the appraisal with the cadet and various aspects were discussed. This procedure followed the technique suggested by Carl Rogers in that it was non-directive. The counselor was fortified with considerable objective and subjective information about the cadet which had been gained from a complete cumulative record, a comprehensive report from the commandant of cadets, covering the cadet's personal habits, social relationships, manners, and adjustment to authority, and an assortment of "behaviorgrams". He also had a report provided by

the school chaplain, covering the cadet's progress in religion, together with the chaplain's subjective appraisal of the cadet's religious or moral values.

5. During the course of the individual interview, the counselor had the opportunity to encourage certain strong traits or goals and to "soft pedal" goals which the counselor had reason to believe could not be successfully pursued.

6. When a cadet was discovered to have hampering emotional elements in his personality, the counselling was continued by the school's clinical psychologist. The cadet was told of the emotional problem and why knowledge alone was not sufficient to overcome this disability. We felt that we were thus following a procedure that has long been known—that most mal-adjustments are not failures in *knowing,* but that knowledge alone is insufficient to rid the individual of the hampering disability. Catharsis and psychotherapy would need to be employed. This fact is too often disregarded by test publishers who advocate telling the student of his maladjustment and then asking him to cure himself by "will-power". It seems to us that this disregards the well known fact that until the cause for the mal-adjustment is discovered and resolved, the individual needs the emotional satisfaction which he achieves through his present mal-adjustment. The area of counselling emotional problems must be reserved for those especially trained for this exclusively professional and personal relationship with the individual. Too many inadequately trained teachers, many of them themselves neurotic, have rushed in to become counselors. It is generally conceded that the desire to give advice on personal matters is a weakness with all of us. Nothing else quite so fully satisfies our own ego but nothing so cheapens counselling as the teacher who relieves her own psychological troubles at the expense of the student.

There is great service to be rendered by adequately trained educational counselors who counsel exclusively on problems of academic achievement, ability and interest, and who recognize an emotional maladjustment which needs to be referred to a clinical psychologist. There is great need for this work which we believe can bring about closer cooperation between the high school and the college, thus reducing the large number of college failures, especially among entering freshmen.

The high school must more adequately interpret to its students the needs and standards of colleges, vocational schools, industry and life to assist the student to a more meaningful understanding of his own preparation before he takes the next step after leaving high school.

home and abroad, including one from Oxford University in England. The article was also reprinted by the Bureau of Governmental Research, University of Kansas, for distribution to the sportsmen of Kansas through the agency of the 105 county clerks of the state. We predict for his article in the present issue on Kansas lakes and recreational areas an equally wide recognition. In addition to the two articles published by the *Transactions,* Dr. Stene has recently completed *Railroad Commission to Corporation Commission,* a study of state public utility regulations, published by the Bureau of Governmental Research, and he has also nearly completed a study of the development of the Kansas State Board of Agriculture. Kansas is to be congratulated in possessing such an able and productive student of her many departments and activities.

A brief biographical sketch of Dr. Stene, together with his portrait, will be found in the March, 1945, issue of these *Transactions.*

* * *

The news column which follows in this issue records numerous additions to faculties of Kansas colleges; such additions appear to be of general occurrence throughout the country. A friend at the University of Ohio recently told the editor, for example, that shortages of housing and competent teachers were their great problems and on a trip to Colorado late this summer, teachers in our sister state reported similar difficulties. One of the more disturbing features, however, of the times, is the large number of resignations, including many from our younger and abler men, recorded in this issue. (Note that those resignations include only those in the sciences). Nearly all of these resignations come as a result of increased pay and increased professional opportunities in larger schools outside the state. Kansas colleges and universities should not become merely training grounds for competent teachers and researchers in securing experience before going on to other fields of activity. The matter should have the immediate attention, not only of our college administrators, but of teachers themselves and the Kansas public generally.

St. Paul's Advice to Teachers

If the trumpet give an uncertain sound, who shall prepare himself for war? So also ye, unless ye utter by the tongue speech easy to be understood, how shall it be known what is spoken? For ye will be speaking into empty air.

Index — Volume 49

Original articles are entered under the name of their fields (Archeology, Chemistry, etc.), under the name of the author (given in italics), and under the title, usually abbreviated (and also in italics).

Transactions

OF THE

KANSAS ACADEMY OF SCIENCE

Established 1873

VOLUME 50

(For Contents, see Index, page 366)

Published by the Kansas Academy of Science

1947

Manuscripts for publication or other communications concerning the *Transactions* should be addressed to the editor, Dr. Robert Taft, University of Kansas, Lawrence, Kansas.

Correspondence concerning exchange privileges should be addressed to the director of one of the following libraries:

1. University of Kansas, Lawrence, Kansas, or
2. Kansas State College, Manhattan, Kansas, or
3. Fort Hays Kansas State College, Hays, Kansas

Volume 50 of these *Transactions* was published in three parts as follows:

Volume 50, No. 1, June, 1947, issued June 30, 1947

Volume 50, No. 2, September, 1947, issued September 30, 1947

Volume 50, Nos. 3 and 4, December, 1947, issued December 30, 1947

Transactions
Kansas Academy of Science

Volume 50, No. 1 June, 1947

Prehistory and Environment in the Central Great Plains*

WALDO R. WEDEL
Associate Curator, Division of Archeology, U. S. National Museum, Washington, D. C.

In the June, 1946, issue of these Transactions, *the history and archeology of the Kansa Indians was presented to our readers by Dr. Wedel. In the present article, taking a broader viewpoint, Dr. Wedel reviews briefly and understandably the historic and prehistoric native cultures centering about the Great Plains region in present Kansas and Nebraska. Dr. Wedel proceeds farther than a most interesting description of these cultures, however, for he attempts to show the significance of the archeologist's findings to some of the regional problems of the present day. This review was presented as the principal public address of the 79th annual meeting of the Academy in Lawrence on April 3, 1947. For a personal history of Dr. Wedel, the reader is referred to the June, 1946, issue of the* Transactions.—THE EDITOR.

In the past decade or two, we have witnessed a growing interest in the interaction of man and environment in the Great Plains. Devastating droughts, dust storms, and successive crop failures, with their resultant economic, social, and political repercussions, have been written up in books and pamphlets, discussed in conferences, and pondered by governmental agencies. The realization has come, and forcefully, that for the farmer and those dependent on his welfare there are grave and recurrent climatic hazards to winning a livelihood in the region. Abandoned farms and homes, and the widespread belief that the Great Plains should be given to the bison and the Indian, are testimony to the impact of these climatic shocks on present-day inhabitants. The suggestions of geographers and others that a carefully-planned long range program of land utilization might help to forestall such disasters are either ignored, or else are forgotten when the rains begin again.

As an archeologist, I propose no remedy for the many and pressing problems flowing from the vagaries of Great Plains climate. Instead, I wish to review certain findings of archeology in the region,

Transactions Kansas Academy of Science, Vol. 50, No. 1, 1947.
*Published with approval of the Secretary of the Smithsonian Institution.

and to indicate how the pre-white inhabitants reacted to the opportunities and limitations of their environment. It is evident that long before the first Spanish and French explorers ventured onto the Great Plains, the region was being exploited in different ways by a succession of native peoples. Also, there seems to be good evidence that some of these peoples may have been faced with problems similar to those confronting man here today. The area is enormous, the workers are few, and the data still scanty; but it may be worthwhile to see where the available evidence points.

The Great Plains have been variously defined by different writers, depending on the direction and purpose of their particular approach. Here we shall restrict ourselves to what I have elsewhere termed the central Great Plains—that portion of the erstwhile "Great American Desert" included in the states of Kansas and Nebraska. It has been aptly observed that the Plains cannot really be divided, that they represent a unit, and that no matter in what detailed manner we may discuss any section the over-all view should be kept in mind. With this thesis I agree, and therefore I shall not hesitate to pass beyond the arbitrary bounds of our "central" section where necessary.

The traveler across Kansas and Nebraska, if he follows one of the main railroads or highway routes, is likely to find the region monotonously uniform and much of it uninteresting. It has been characterized as a land of low relief, few trees, and little rainfall—of sun and wind and grass. Closer inspection will show, however, that there are significant variations from section to section. These variations, for hundreds of years past as today, had and have direct bearing on man's utilization of the region.

Topographically, the western portion of the area is a part of the High Plains—the remnant of a great outwash plain which in Tertiary times extended from the Rocky Mountains into eastern Kansas and Nebraska. The High Plains are a broad, monotonously flat upland which becomes uneven or gently rolling toward the north and increasingly flat toward the south. Streams descending from the mountains, such as the Arkansas and Platte, flow eastward across this belt in wide, flat-floored valleys of gentle gradient. Within the High Plains rise lesser streams, running in shallow open valleys that often give way to picturesque canyons. With rather surprising frequency, these secondary valleys contain permanent springs; from them issue perennial streamlets bordered by verdant valleys that contrast strikingly with the semi-arid uplands. These have

provided, for uncounted centuries, excellent camp and village locations for primitive man; and the archeological record shows that man has not ignored their attractiveness. Except where they have been placed under cultivation, the uplands are dominated by buffalo and grama grasses, with some yucca, cactus, and sagebrush. In the valleys are scattered groves of cottonwood, hackberry, and willow, with some elm and ash. Thickets of wild plum, elderberry, chokecherry, and other edible native plants are scattered along the ravines and stream valleys. Juniper grows along the valley rims, and it is rather probable that at one time stands of western yellow pine occurred eastward to south central Nebraska. Native game included the bison, antelope, mule deer, and other smaller forms, as well as the prairie chicken and grouse.

East of the High Plains the terrain changes. South of the Republican River, in north-central Kansas, lies a highly dissected area known as the Plains Border. Here the Smoky Hill, Saline, Solomon, and their tributaries have created a belt of high plateaus and prominent east-facing escarpments, with isolated buttes and ridges prominently developed. The streams are fringed with oak, elm, walnut, cottonwood, and other hardwoods, while bluestem and bunchgrasses clothe the slopes and uplands. Native game includes all the larger forms found on the High Plains, together with beaver and numerous other fur-bearers more typical of areas to the east.

North of the Platte in Nebraska are the Sandhills, a hilly, almost treeless, bunchgrass area dotted with lakes, ponds, marshes, and hay flats. Streams are few in number but carry an abundant flow of good water throughout the year. Wild rice grew in some of the shallow lakes, and seems to have been an important native food source. Waterfowl were numerous about the lake margins, and fur-bearing animals abounded along the watercourses.

East of the Plains Border and Sandhill areas formerly lay a bluestem and prairie-grass region. In eastern Nebraska, with a long tongue running westward between the Platte and Republican rivers are the Loess Plains. Southward, these merge into the unglaciated rolling Osage Plains of eastern Kansas. Throughout all this region the major streams flow in broad, bluff-lined, often terraced-bordered valleys. Fine stands of burr oak, elm, walnut, hickory, sycamore, etc. line the stream banks. Food plants include the wild grape, plum, mulberry, chokeberry, and a number of tuber-bearing forms. In eastern Kansas, and of economic importance to early peoples, were the Osage orange or bois d'arc, papaw, persimmon, pecan, and dog-

wood. Native game included the wolf, bear, otter, beaver, cougar, wildcat, opossum, rabbit, and others, in addition to bison, elk, and deer. Present, too, was the wild turkey. As this recital suggests, the natural resources of this eastern section were very much greater than in regions farther west. Also, precipitation was heavier, the soils generally deeper and richer, and agriculture much more certain and rewarding.

From the viewpoint of the farmer, whether modern or aboriginal, perhaps the most important factor in utilization of the Great Plains by man is climate. As a whole, the region is characterized by warm sunny summers, cold dry winters, and considerable windiness throughout the year. In the central portion, as defined here, there is a frost-free growing season of 150-200 days. Precipitation decreases from about 40 inches in southeastern Kansas to 15 or 18 inches in western Kansas and Nebraska. Because of the dry winters, the stored soil moisture is usually scanty, and crops depend chiefly on the rainfall during the growing season. In this respect, the average annual precipitation is favorably divided, since about 70 per cent falls between April and September.

Unfortunately, averages are of less significance here than are the freaks of the season. Throughout much of the area, the yearly average is close to the minimum crop requirement, and so the variations assume great importance. Weather records indicate that there is "less than the normal amount of rainfall in more than half the years." These variations from average are of uncertain duration, do not come in regular succession, and cannot be forecast with accuracy.

Droughty conditions are often attended in summer by prolonged periods of high temperatures. Warm southerly winds of high velocity promote rapid evaporation. Well-known to all residents of the area are the "hot winds" with shade temperatures up to 100° to 110°. These may seriously damage crops in the space of a few hours; if prolonged for several days, widespread crop failures result. Many farmers insist that these hot winds can destroy the corn crop even where soil moisture may be adequate for the normal requirements of the growing plants.

When white men from the eastern United States first began to enter the trans-Missouri plains in numbers soon after 1800, they found them inhabited by Indian tribes of diverse languages and ways of life. Collectively, these tribes have been termed the Plains Indians. The picturesque costumes and customs, superb horsemanship, and stubborn fighting qualities of many of these peoples

made a deep impression on the whites, and in the popular consciousness it was the Plains Indian who shaped the concept of what an Indian was. Here, again, closer scrutiny shows that not all the Indians were alike, either in mode of life or in their historical background.

An imaginary line, through the present cities of Great Bend, Kansas, and Kearney, Nebraska, paralleling roughly the 99th meridian, may be regarded as the approximate dividing line between the Great Plains on the west and the true prairies or prairie plains

Fig. 1.—A typical Plains Indian hunting camp of the nineteenth century. Photo by S. J. Morrow, probably made in the upper Missouri Valley about 1870; courtesy Bureau of American Ethnology.

on the east. It will also serve as a line between two strikingly divergent native subsistence economies in the central Great Plains during the 1800s. To the east, where soil and climatic conditions are now recognized as most advantageous for cultivated crops, the native economy was based on horticulture with hunting secondary. West of this line, where the plow has transformed the land periodically into a dust bowl, hunting was of primary importance.

During the 1800s the High Plains and the Plains Border immediately to the east were the range of the bison herds. Closely dependent on these animals were a group of tribes which may be designated the migratory bison hunters. These included from south to north, the Comanche, Kiowa, Cheyenne, Arapaho, Dakota, and others beyond our immediate area. From the spring of each year until fall these Indians followed the herds, subsisting principally on the flesh of the bison and drying great quantities of meat for winter consumption. The winters were spent in sheltered spots where water, wood, and forage for the horses were available. The portable skin tipi was universally used. Skin-working was highly developed; agriculture and pottery-making were virtually nonexistent; and implements and utensils were limited to essentials that could be easily carried on horseback from camp to camp. Wild fruits, nuts, berries, and roots supplemented the meat diet; corn was obtained by barter or theft from other tribes who raised it. Warfare and horse-stealing took up much of the time of the men. No fixed tribal boundaries were recognized, and the distances ranged by the various tribes in hunting and raiding often totalled many hundreds of miles. These were the so-called "typical" Plains Indians; and it was they primarily who, from Texas to Canada, disputed the westward expansion of the Americans in post-Civil War days.

East of the 99th meridian, since the coming of the whites, have dwelt chiefly Siouan- and Caddoan-speaking tribes. These included the Osage and Kansa in eastern and northeastern Kansas, the Oto, Missouri, Omaha, and Ponca in eastern Nebraska, the Pawnee on the Loup and Platte rivers of east central Nebraska, and north of our area the Arikara, Mandan, and Hidatsa along the Missouri River in South and North Dakota. At the beginning of the white contact period in the 16th century, there appears to have been a group of Wichita settlements in the Arkansas drainage of central Kansas, but these were given up during the early 18th century. All these tribes dwelt in large, more or less fixed villages located near streams where wood, water, and tillable ground were available. Their habi-

tations (Fig. 2) were circular earth-, bark-, or grass-covered lodges. Maize, beans, and squash were cultivated; wild fruits, nuts, berries, and roots were gathered; and once or twice each year the entire village population departed on a lengthy communal buffalo hunt. During these hunting excursions, the people lived in skin tipis, hauled

Fig. 2.—Pawnee village on the Loup River near Genoa, Nebraska; typical of many earth-lodge villages formerly inhabited by the semisedentary Indians of Kansas and Nebraska. Photo by W. H. Jackson, 1871; courtesy Bureau of American Ethnology.

their equipment on horseback or by travois, and lived in general like the migratory bison hunters. Those movable possessions that could not be carried along were buried in underground caches. Before 1800, all these tribes made pottery, and also had fairly well developed work in stone, bone, horn and other materials.

The native agriculture of these peoples merits brief notice. Strictly speaking, it was not agriculture, or field farming, but horticulture, or gardening. The corn patches were small, from one-quarter to three or four acres in size. These were tilled by the women with the aid of a sharpened stick and a bone hoe. Unable to conquer the tough prairie sod, the Indians confined their tillage to bits of alluvial soil along the creek banks or at the mouth of a ravine. This meant that in the neighborhood of large villages the women sometimes found it necessary to travel 5 to 8 miles or more to find suitable

ground. The gardens were hoed once or twice during the early growing season, then left to themselves until the villagers returned from the summer hunt to harvest the crops. Corn yields varied with the season and other factors, but estimates run from 15 to 25 bushels per acre under native methods. Surplus crops were dried and stored in cache pits in or outside the houses. These pits or Indian cellars, ranging in size up to 8 feet in diameter and 10 feet or more in depth, are a common feature of every central Plains village site where corn-growing is evidenced. When the foodstuffs were taken out, or spoiled as a result of prolonged wet weather, the storage pits were adapted to the dumping of floor sweepings and general village refuse.

The picture we have just sketched of 19th century Plains Indian life has extremely interesting, if not generally known, antecedents. In the first place, it is evident that the horse-using migratory nomads were a relatively late development. The horse spread rather slowly from the Spanish settlements before 1700, and seems not to have been universally adopted by the Plains Indians until 1750 or later. Even the tribes so strongly linked with the plains horse culture are, in part at least, late arrivals; the Comanche did not come into the area until about 1700; the Cheyenne, flower of Plains chivalry, were corn-growers in eastern North Dakota as late as 1750, and crossed the Missouri not long before 1800. In pre-horse days, travel in the western plains was on foot, the dog was the only draft animal, village units were small, and the wandering hunters presumably were largely on a pure subsistence basis. Archeology shows, moreover, that in earlier days corn-growing Indians lived in relatively settled communities far to the west of the 99th meridian.

For our purpose, it is immaterial whether the Wichita or the Pawnee or the Mandan, as such, were early or late comers in the Missouri Valley area. What is important is the fact that the sedentary mode of life of these village Indians in somewhat more subdued form goes back several centuries before the coming of the white man. Avoiding so far as possible the technical phraseology of the archeologist we may review briefly the picture of pre-nineteenth century Indian occupancy as it is now envisioned.

In 1800, central and western Kansas were hunting range for the Kansa, Osage, and Pawnee; the Pawnee hunted also in southwestern Nebraska, and the Dakota roamed the Nebraska panhandle. Yet a hundred years before, another people who may have been

Apache but who are known to archeologists as the Dismal River culture, had settlements in what is now Scott County, Kansas (Fig. 3), on the Stinking Water Creek in southwest Nebraska, and at

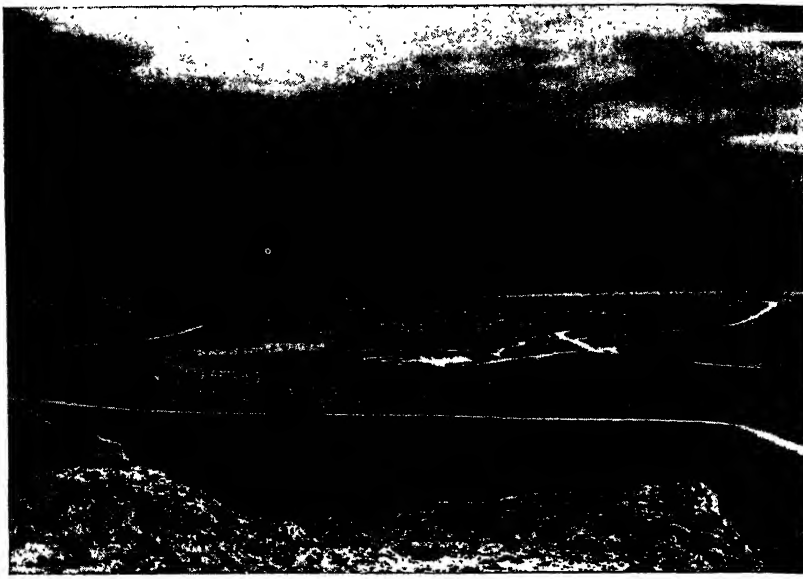


Fig. 3.—Beaver Creek Valley in Scott County State Park, western Kansas. An early 18th century Pueblo ruin, surrounded by remains of a possible Apache occupation, lies near the center of the view.

numerous other points west of the 100th meridian. These people had corn and squash, made pottery, probably hunted much more intensively than they gardened, were in contact with southwestern peoples, and had sufficiently permanent settlements to leave considerable quantities of refuse. If these plainsmen were Apache, it may be suspected that their disappearance by the mid-18th century is linked with arrival of the Comanche.

At an earlier date, in central Kansas, flourished a number of large settlements that have been tentatively identified with the Quivira towns visited by Coronado in 1541. There is no evidence that their inhabitants used horses. Again, the quantities of refuse argue for a fairly sedentary and prolonged occupancy. Innumerable fragments of bone hoes are present, and there is direct evidence for corn-growing on an intensive as well as extensive scale. Charred well-formed ears of 10-, 12-, and 14-rowed corn have been recovered; they are superior to corn found archeologically at most other Plains

sites excavated to date, and corn geneticists have pronounced them a "well-fixed high type." They suggest a long background of development. Underground caches are of great size and number, which I take as indication of abundant crops. These people traded with the pueblos of the upper Rio Grande, for in their sites have been found turquoise, obsidian, and painted pottery by means of which we establish the period of their occupancy. Bits of chain mail and a few other objects of white man's manufacture show that there was a very limited contact with Europeans, probably the Spanish on the Rio Grande. When these Indians entered Kansas and why they left are unsolved questions; perhaps, in the latter connection the Comanche, or else the Siouan Osage and Kansa from the east, were responsible.

In east central Nebraska at about this same time, the Pawnee were residing in large compactly-built towns, often fortified or else located on elevations that would suggest an eye to defensibility. There is direct evidence of corn, beans, and squash; cache pits are large and numerous; and bone hoes are abundant. The horse is not indicated, but large dogs presumably served as draft animals. The house type conforms more closely to native Pawnee tradition and ritual than does that of the 1800's, and the remains generally indicate a more vigorous, active, and apparently richer culture than that which the later white travelers saw and recorded among the Pawnee.

Earlier than any of the peoples considered above were those designated by archeologists as the Upper Republican and Nebraska cultures. The Nebraska culture remains occur principally along the Missouri River bluffs above the mouth of Kansas River to the Niobrara; the Upper Republican peoples lived to the west, their remains having been found as far as Lane County, Kansas, and throughout the Loess Plains of Nebraska to a point in northeastern Colorado. Both peoples dwelt in semisubterranean earthlodges, much like those of the historic Pawnee except that they were square in floor plan. They grew corn, beans, and squash, used the bone hoe, and stored surplus crops in small cache pits. They were not in contact with white men and did not have the horse. They lived in small, rambling communities, unfortified and without evidence that considerations of defense were involved. Pottery and implements of stone, bone, etc. are fairly plentiful on the sites of these villages. The abundance of sites attributable to these people, and their very wide distribution throughout those portions of the central Great Plains that today are considered best suited for corn-wheat agriculture sug-

gests that they had a reasonable firm hold on the region for a considerable period of time. It is estimated that they lived here between *ca.* 1250 and 1500 A.D.

Underlying the Upper Republican and Nebraska culture remains are yet older materials broadly termed Woodland. They are often deeply buried; sites tend to be small and not very prolific; and so we know very little about the people who left them. They did make pottery, and tools of stone, bone, and horn. Corn has been found on only one or two sites, and bone hoes are rare or absent. If horticulture was practiced, it seems to have been rather perfunctory and of far less importance than hunting. Certainly the evidence from most of these sites suggests a less sedentary mode of life and perhaps a less secure hold on the region than was characteristic of Upper Republican, Nebraska Culture, and later peoples.

This ends our brief and incomplete catalog of the principal known native peoples who, during perhaps a thousand years preceding the 1800s, certainly or probably sought a livelihood through pursuit of horticulture in the central Great Plains. It by no means exhausts the list of peoples for whose former existence in the region there is archeological evidence. Long before the first use of domestic crops here, other groups evidently sought their livelihood through hunting and gathering. Best known of these are the Folsom bison-hunters, whose ancient campsite near Fort Collins, Colorado, has been under study by Smithsonian and other scientists for a number of years. Probably later in time are the Yuma remains, which like the Folsom finds, have come to light principally in the semi-arid High Plains. From their association with extinct fauna and also from certain geological evidences, the Folsom remains have been tentatively dated at 10,000 to 25,000 years ago. Whatever the correct figure, it seems clear that the interval between these ancient bison-hunters and the first potters and possible horticulturists of the area was a very long one. What was happening during that interval is still partly conjectural, but a number of sites with some depth of deposit in the western plains offer possible clues. These consist of strata of camp refuse, animal bone, worked stone and artifacts that cannot be convincingly assigned to late farming or historic hunting peoples. What they probably indicate is a series of occupations by non-pottery making hunter folk who eked out a rather slim existence through hunting and the gathering of roots, seeds, and berries. Future fieldwork in the arid parts of the Great Plains may be ex-

pected to throw light on this problem, though it may be doubted that the period will be very well known for a long time to come.

Incomplete though our present knowledge of the Plains Indians admittedly is, one point emerges rather clearly. I refer to the distorted and one-sided picture which most writers on the area have given us. Even that able student of the Great Plains, Professor Webb, writing before the findings of archeology were generally available, has characterized the Plains Indians as nomadic warriors "by nature more ferocious, implacable, and cruel than the other tribes" and as "the least civilized of all the tribes." Actually, as Strong has pointed out, "the late nomadic and hunting life of the central Plains appears merely as a thin overlay associated with the acquisition of the horse." As to their savagery, apart from the fact that it doubtless stemmed in large part from the ruthlessness and double-dealing of the white man, it has not yet been convincingly shown that it exceeded the treatment frequently accorded to red and white foe alike by the "civilized" Indians of the eastern United States.

As archeological facts replace conjecture for the pre-Columbian history of the Plains, the story of man's response to his environment here takes on a new significance. Abundantly suggested is the fact that the natural environment here, as elsewhere, has offered throughout the centuries opportunities for development along more than one line, that man has attempted in various ways to meet the challenges of that environment, and that in his successes and failures lies a long and fascinating story of human endeavor. I should like to recapitulate briefly that story, and to show a little of what has been involved in the way of interaction of culture and environment in this region.

So far as we know today, the oldest human remains in the central Great Plains are represented by the Folsom culture. If older materials exist, as is not at all unlikely, they are still undiscovered or unrecognized. It is noteworthy that the Folsom remains, like those of the Yuma and other vaguely known later non-pottery cultures, have been found chiefly in the now arid western portions of the region. From western Kansas into Colorado, Nebraska, Wyoming, and Montana, many sites are in locations that today would not provide water or food for a human population, and where none but the rank novice or the incurable specialist would look for signs of human habitation. There is physiographic evidence of changes in the landscape since some of these sites were occupied. Remains of animals now extinct

occur with Folsom materials; from this and associated invertebrate fossils, charcoal fragments, and other data it appears that these big-game hunters lived in a moister and cooler climate than that which prevails today. All of this suggests that the early hunting peoples, instead of avoiding the western plains or venturing hesitantly out from the sheltering foothills into a bleak and inhospitable near-desert, actually made use of an environment whose advantages for man were much more obvious then than now. That these peoples further reacted to their surroundings by exterminating some of their food animals and altering their floristic environment through frequent fire-drives, as some have suggested, is an interesting but unproved theory.

Unlike the ancient bison-hunters, the corn-growing Indians who began settling the Plains perhaps a thousand years or more ago pretty certainly came from the east or southeast. Their crops, their implements and industries, their habitations and burial customs, even the skeletal remains of the people themselves where available show unmistakable relationships to Mississippi Valley peoples rather than to western groups. The earliest of the pottery-making Indians to arrive, as pointed out above, were apparently those called Woodland; and here evidence of horticulture is meager and indecisive. The sites are most plentiful in the eastern plains, diminishing in number and apparently in richness as their distance west of the Missouri increases. The known sites are small, often well concealed on inconspicuous creek terraces, and suggest transient hunting camps rather than well established communities. By comparison with later sites, they impress one as a cautious and uncertain movement by an easterly people or peoples into a new and unfamiliar environment. It may well be that these Indians, with a long background and tradition of life in the forests paused, like the later white man, for a deep breath at the edge of the "grand prairie ocean" before venturing forth to try their luck at wresting a living from the Great Plains environment.

How long the people we call Woodland occupied the trans-Missouri plains we have at present no way of knowing. Ultimately, perhaps for climatic reasons, they seem to have withdrawn or disappeared. After a time, another people came into the region, and established themselves on what looks like a far more secure basis. These, the Upper Republican and Nebraska Culture peoples, came in sufficiently leisurely fashion to spread their remains over almost every arable creek and stream valley where water was reasonably

sure as far west as the Colorado line, perhaps even beyond. Their villages were nearly always placed along the smaller waterways—a few houses here, a few more there, and usually on flood-free terraces with arable bottoms nearby. Corn, beans, and squash, preserved by charring, have been found in many of their sites. Presumably their horticulture was much like that of the historic Pawnee; but their storage pits are almost invariably much smaller, perhaps also less numerous per house unit, than those of the later peoples. This suggests a less intensive farming pattern—or perhaps less productive crop varieties than those of later years. The archeologist, unhappily, has been remiss in not insisting upon a careful study by specialists of the crop remains he has unearthed; and as a result we are uncertain how these early corn varieties, for example, compare in quality with the later.

At a time probably not much preceding Coronado's march to central Kansas in 1541, the widespread little earthlodge communities of the Upper Republican peoples in the western plains seem to have been abandoned. From the early Spanish and French accounts, it appears that the semisedentary peoples of the 16th century and later in the central Great Plains lay for the most part east of the 98th or 99th meridian. The villages were much larger, fewer in number, and were compactly arranged. Coronado's chroniclers, e.g., speak of villages of 200 lodges in Quivira; and while the accuracy of these early estimates is not above suspicion, archeology certainly confirms the conclusion that these and contemporary towns to the north were of considerable size.

This period, for perhaps a hundred years or more after Coronado's visit, seems to have been the highwater mark of central Plains village Indian culture. From central Kansas northward through Nebraska, the sites from that time level generally yield the most varied, most abundant, and in many respects, the most advanced material culture remains. Horticulture was practiced intensively as well as extensively; crops must have been large, and the surplus for storage or barter considerable. Quite possibly it was this accelerated and improved agriculture, with heavier crop yields from new varieties of plants, that made possible life in large communities; and this community life, in turn, stimulated a florescence of culture. It appears that these large communities were in existence even before the horse was available to increase mobility and thereby to vastly expand the available food resources. The village Indians known to the white

men after 1800 were the weakened and disintegrating remnants from this early historic climax.

The remarkable accomplishments of the red man in spreading agriculture westward into the Great Plains and northward up the Missouri Valley are not generally appreciated by his modern successor. In this region we have, as Will has pointed out, "perhaps the harshest climate to be found in the temperate zone of North America, yet the cultivation of crops was carried well toward the northern limits of this area." From a subtropical plant requiring 130 to 200 days to mature, killed by a touch of frost, and hardly able to hold its own at temperatures below 60° F., the Plains village Indians as they moved west and north developed compact, deep-rooted, early-maturing, frost- and drought-resistant varieties of corn. The most impressive illustration of this extreme specialization was seen in historic times among the Upper Missouri tribes—Arikara, Mandan, and Hidatsa. Here the early settlers found flint, flour, and sweet corn in surprising variety—as many as 15 varieties in the case of the Mandan. Varietal diversity was no accident; the Indians knew that corn cross-fertilizes, and took care to keep different strains from mixing. Whatever comparable specialization against drought and other environmental drawbacks may have taken place earlier in the western plains of Kansas and Nebraska remains for archeology and the corn geneticist to disclose. In any event, it is a safe inference that the varietal specializations of corn among the Plains Indians were not an overnight development, or the result of chance; rather they represent a purposeful effort to adapt a subhumid plant to a new and radically different environment. If the agriculture of these Indians seems small scale and their yields unimpressive when compared to the performance of eastern horticultural tribes, we would do well to reconsider and re-evaluate their achievement in light of the environment they were facing.

What I have said up to this point may seem irrelevant from the practical viewpoint of today—an interesting story of what is now past and might as well be forgotten. I believe, however, that there is one more facet of the problem that may have direct applicability.

The Great Plains are a borderland between the arid West and the humid East. As such, they are subject to recurrent droughts of varying duration, intensity, and frequency. It is interesting to note that the cultural deposits from which the archeologist derives his data on prehistory furnish him as well with a possible explanation of what happened to some of the aboriginal corn-growing peoples. Thus,

e.g., in the western Plains the artifacts and occupational deposits of the corn-growing Indians are often covered by a few inches to several feet of wind-laid soil (Fig. 4). Where two or more peoples

Fig. 4.—A prehistoric Upper Republican Indian village site (Stratum B) covered by twelve inches of wind-blown dust (Stratum A). Davis Creek near Cotesfield, Nebraska.

have left their remains on the same spot, wind-deposited strata often separate the archeological horizons (Fig. 5). Moreover, the artifact-bearing strata commonly seem to be directly associated with old humus zones that probably represent a former ground surface. That is to say, terrace building was not a steady process of wind aggradation, but rather was a series of active building stages interrupted by periods of relative stability of surfaces now buried. What is evidently implied is the presence of Indians in settled communities during periods of arrested deposition and humus formation, their absence during following periods of active soil accumulation. That these intervening periods of active deposition may have been of some length is suggested by the marked dissimilarities in the cultural materials they separate. In other words, the people who reoccupied a given site after formation of the sterile layer were not the same ones who had lived before—their implements and utensils, their presumed habitations, often their mode of life and even their physical appearance were distinctly different. Evidence is accumulating that suggests similar successions may be characteristic of the pre-pottery hunting peoples of the Plains, and also that similar phenomena

may have taken place over a very wide area. There is reason to believe that tree-ring studies may some day soon give us actual dates for these events.

In another place, I have summarized archeological evidence for prehistoric droughts in the Great Plains. The evidence, it should be emphasized again, is spotty and incomplete; the archeologist

Fig. 5.—Stratified site on Salt Creek, Lane County, Kansas. Strata A, B, and probably C represent a series of successive prehistoric Indian occupancies, separated by wind-blown deposits (Strata D) containing no archeological remains.

urgently needs the help of the geographer, the soils expert, and other specialists to amplify and perhaps to correct his interpretations. Meanwhile, I submit again that if the repeated interludes of deposition were indeed the aftermath of decreasing rainfall and increasing

wind activity, as contrasted to the more humid periods which produced the humus zones, we may visualize the farming Indians as having ventured far out into the Great Plains during favorable times only to withdraw when periods of rainfall deficiency and wind deposition set in.

As an archeologist, I am perhaps stepping out of character in making one final observation. In light of the findings of archeology, I question the thesis that dust storms were of minor consequence before the plow broke up the grasslands. On the contrary, cold comfort though it be, it appears likely that the climatic vicissitudes experienced by the whites in the Great Plains in 1860, 1870, 1893-96, and especially during the 1930s, are a repetition of an old story—and that the future, if we may judge from the indications of the past, probably holds in store more of the same. The hope for improved living and greater economic security in the Plains, if it be hope merely as a matter of faith, is not enough. Man, to be sure, cannot control the weather, but the engineer knows devices that will control floods and in many instances mitigate the disastrous effects of drought. Lasting betterment for the region can come only through hope implemented by an intelligent attack on these problems with all the technological and scientific resources available to modern man.

Suggested References

Bell, E. H. (Editor) 1936. Chapters in Nebraska Archeology. Vol. 1, Nos. I-VI. Lincoln.

Champe, J. L. 1946. Ash Hollow Cave. Univ. of Nebraska Studies, New Series No. 1.

Roberts, F. H. H., Jr. 1940. Developments in the problem of the North American Paleo-Indian. Smithsonian Misc. Colls., Vol. 100, pp. 51-116.

Strong, W. D. 1935. An Introduction to Nebraska Archeology. Smithsonian Misc. Colls., Vol. 93, No. 10.

Webb, W. P. 1931. The Great Plains. Ginn and Company, Boston.

Wedel, W. R. 1938. Some problems and prospects in Kansas prehistory. Kansas Hist. Quart., Vol. VII, No. 2, pp. 115-132.

——— 1940. Culture sequence in the central Great Plains. Smithsonian Misc. Colls., Vol. 100, pp. 291-352.

——— 1942. Environment and native subsistence economies in the central Great Plains. Smithsonian Misc. Colls., Vol. 101, No. 3, pp. 1-29.

——— 1947. Culture chronology in the central Great Plains. Amer. Antiq., Vol. 12, No. 3, pp. 148-156.

Will, G. F. and Geo. E. Hyde. 1917. Corn among the Indians of the upper Missouri. St. Louis.

The Editor's Page

Transactions
of the
Kansas Academy of
Science
Published Quarterly
by the
KANSAS ACADEMY OF SCIENCE
(Founded 1868)
OFFICERS
John C. Peterson, Manhattan, President.
F. C. Gates, Manhattan, Secretary.
S. V. Dalton, Hays, Treasurer.

Vol. 50, No. 1 June, 1947

ROBERT TAFT, *Editor*

Following the annual meeting of the Academy in April—a report of which will be found on page 97—President John C. Peterson called a meeting of the Academy Council in Manhattan on May 17th. Interim Council meetings initiated by Dr. W. J. Baumgartner during his term of office as president in 1935, have proved of genuine benefit in stimulating the activities of the Academy and the meeting of May 17th was no exception. President Peterson outlined a proposed program for the 80th annual meeting at Pittsburg next spring and after extended discussion a plan for the meeting was agreed upon. It is still too early to announce the proposed program but it can be said that if the plan as proposed materializes it will be worthy of the largest attendance an annual meeting of the Academy has ever had.

In addition to plans for the next annual meeting, other activities of the Academy were discussed. The work of the committee on conservation was considered especially at some length, objectives for the committee set and a fund of $100.00 set aside for their use. This committee has the opportunity of becoming one of the most important of the Academy and it is hoped that its members will realize its importance and their responsibility. In a state almost completely lacking in a trained conservation personnel and lacking also a long-range conservation program, it should be the concern of some public-spirited organization to lead the way in developing this neglected aspect of the state's activities. To the editor's mind, the Kansas Academy of Science should be the logical leader in this development.

Attention to the matter of conservation in Kansas has already been the subject of editorials on these pages for several years past and doubtless will continue to be a subject considerably discussed.

In the December (1946) issue of these *Transactions* mention of conservation activities in our neighboring states was made. For the benefit of the Academy Conservation Committee and all other members of the Academy, a brief summary of the activities of the Missouri Conservation Commission as included in their last *Report* covering the period January 1, 1945 to June 30, 1946, may be instructive. The work of

the Missouri Commission is reported under many headings including "Regulation," "Enforcement," "Game Management," "Development," "Fisheries Management," "Forestry," "Field Service," "Information," "Education."

Under "Enforcement," for example, the statement is made

> Wildlife Conservation Agents are selected exclusively from men who have participated in competitive examinations and who have met the standard qualifications and earned a place on the eligibility list. Replacement Agents, employed on a temporary basis during the war, and other applicants for permanent jobs, were given opportunity to qualify for positions as Conservation Agents at examinations held May 25, 1946. Those selected must serve six months as probationary agents. Although periodic regional conferences were held for review of policies and procedures, no training conferences were held during the 18 months. Plans were made, however, for their resumption.

The Missouri forestry program is also discussed at some length in the report which states that "The ultimate objective of the present forestry program is to assure the management of woodlands for sustained yield of timber and for maximum production of related crops and benefits—wildlife, public recreation and watershed protection. *Public support of this forestry program is essential.*" The last sentence has been italicized by the editor because recognition of any conservation program—it scarcely need be said—rests on public recognition and approval. In this connection, the Missouri Commission has developed an extensive program of education, both for youngsters and adults. Through school and community leaders, local conservation clubs known as Missouri Nature Knights provide activities contributing to the individual development of each boy and girl who participates, teaches conservation, and allows youngsters to make actual contribution to constructive conservation practices. For example, in the period covered by the report, Nature Knights planted nearly 15,000 trees and shrubs for re-forestation and wildlife protection, protected over 200,000 acres of farm woodlot and pasture land from burning, established 137 wildlife areas of at least one acre, and over 1300 of the Nature Knights made public talks on some conservation topic. The long-range effect of this program of education can only be imagined. In passing, it might be observed, that activities similar to that of the Missouri Nature Knights, could be well taken over by Junior Academies of Science in Kansas giving a year-round program now lacking in our present system.

Wildlife in this country is only a vestige of what it once was; yet even so the return from it to agriculture and industry is probably half a billion dollars annually. We can increase that return substantially by means which also protect other important natural resources. The restoration of wildlife to barren areas requires the planting of vegetation and the protection of water levels. These measures check soil erosion, help to prevent floods, and even mitigate the effects of drought on farming areas nearby. Maintaining vegetation is the best means of conserving soil moisture and soil blowing.—Henry A. Wallace, Report of the Secretary of Agriculture to the President of the United States, 1936.

Scientific News and Notes of Academy Interest

Items for this column are solicited from all Academy members. For inclusion in any given issue they should be in the editor's hands at least three weeks before our publication dates, namely the fifteenth of March, June, September and December.

April 22, 23, and 24, 1948, have been tentatively set for the eightieth annual meeting of the Academy at Kansas State Teachers College, Pittsburg. President Rees H. Hughes and Dean Paul G. Murphy of the College are in charge of the arrangements for this meeting and an excellent program and hospitable welcome are assured to members of the Academy.

Dr. A. M. Guhl of the department of zoology, Kansas State College, Manhattan, recently received notice of a $1,000 grant from the National Research Council for the continuation of his studies on the social organization of the domestic fowl. Readers of the *Transactions* may recall one of Dr. Guhl's articles on this subject which appeared in our issue for March, 1945. The article, judging from many comments made to the editor since its publication, is one of the most interesting to the scientific public which we have ever published.

Through an unfortunate error, the account of the Tribune Branch Agricultural Experiment Station appearing in our last issue (March, 1947, page 383) was credited to Mr. Elbert B. Macy, Station editor of the Agricultural Experiment Station. Mr. Macy writes that the description of the Tribune station was made by Mr. T. B. Stinson, superintendent at Tribune. We are glad to give Mr. Stinson this belated credit for his interesting account.

We are happy to report that Dr. W. M. Jardine, president of the University of Wichita, returned to his office on April 21 following an absence of eight months fully recovered from a serious illness he experienced while vacationing in Colorado last August. President Jardine returned from Honolulu in April where he had spent some months in completing his convalesence.

Dr. Donald J. Ameel, Kansas State College, Manhattan, will spend two months this summer at the University of Michigan Biological Station, Cheboygan, Michigan, on the continuation of a research study begun before the war. The project, a co-operative effort with Dr. W. W. Cort of Johns Hopkins University, concerns the embryology of trematodes.

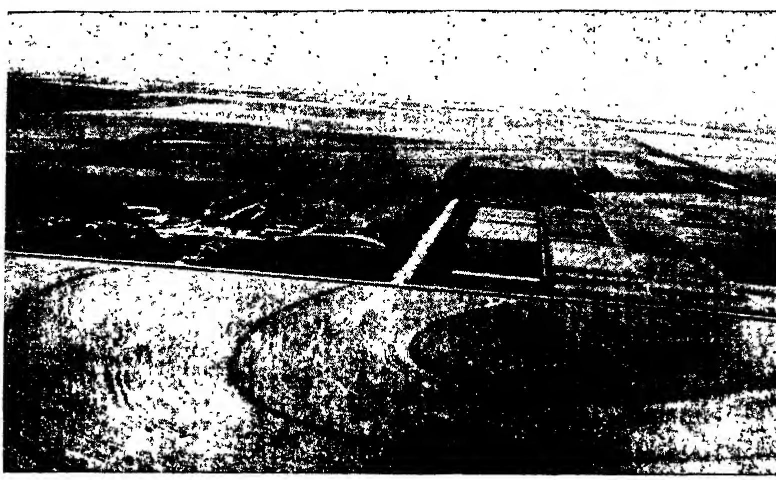
The tenth in our series of brief reviews of research centers in the Kansas area describes the Garden City Experiment Station in western Kansas. The account which follows was prepared for

the *Transactions* by Superintendent Leland Sloan of the Station. Mr. Sloan writes:

Located four miles north-east of the town of Garden City, the Branch Experiment Station was established in 1907 when the Finney County commissioners leased a tract of land for 99 years to the state for agricultural experimentation. The original station comprised 320 acres of virgin buffalo sod, of which 40 acres were broken for the first crop land experiments. The station now consists of 556 acres of land, 100 of which are under pump irrigation.

ment of different crops, and a study of irrigated crop rotations. Principal agronomic experiments are concerned with crop improvement and improved methods of dry land farming and with soil conservation.

Crop improvement projects now being carried out consist of variety, and date and rate of planting tests with all the commonly grown crops; the breeding of sorghums which carry resistance to "Milo disease" and "Weak Neck," as well as other desirable characteristics, and the testing and selection of improved alfalfa varieties for hay, and seed



Garden City Experimental Station—Aerial view from the south.

The Station is cooperative between the State of Kansas, and the U. S. Department of Agriculture, that agency contributing to experiments in dry land agriculture, and soil conservation. Some of the early experimental work dealt with irrigation problems, testing different types and makes of pumps; measurements of the irrigation water require-

production.

The dry land farming phase of the agronomic experiments consist of studying different tillage methods for wheat, sorghums, and summer fallowing; a study of crop rotations, and intensive work on the relationship between methods of tillage and moisture storage.

Soil moisture is at the present

time the principal limiting factor in crop production. Soil moisture studies consist of taking soil moisture samples in one foot cores to the depth to which moisture penetrates the various plots, and correlating the soil moisture percentages with the tillage practices and crop yields. By utilizing the data thus collected it has been possible to calculate mathematically the chances for producing given yields of wheat on the basis of the depth of moisture penetration at seeding time.

The soil conservation experiments are designed to test the various types of "dam" or "basin forming" tillage implements which have come on the market. This project also embraces extensive moisture studies as well as studies of nitrogen and organic carbon changes in the soil.

Livestock has a prominent part in the experimental program at Garden City. The station owns a registered herd of Brown Swiss dairy cattle, and at present is experimenting with irrigated dairy pastures, testing the suitability of various pasture grasses to irrigated conditions in southwest Kansas, and at the same time attempting to work out a pasture management plan for the irrigated district which will provide optimum pasture conditions for a maximum period during the year.

The Garden City Station annually feeds experimentally 500 or more range lambs, testing the many problems which arise in the commercial fattening of range lambs. The experiments to date have been concerned chiefly with such problems as testing the different types and varieties of sorghums, utilizing both grain and forage in lamb fattening rations, testing different weights of lambs, and experimenting on the physical balance in the ration comparing the concentrate and roughage portions in varying percentages.

Registered Brown Swiss cattle grazing on Experimental Irrigation pasture, Garden City Station.

Experimental feeding of 1200

turkeys annually is still another livestock project being carried at the Garden City Station. This experiment is designed to test the suitability of Kansas grown feeds as basic components of the turkey feeding ration.

Mr. Kenneth E. Rose has been appointed associate professor of metallurgy at the University of Kansas, Lawrence. Mr. Rose, a native of Winfield, Kansas, has been a student at Southwestern College. Colorado School of Mines and Cornell University. He received his master's degree from Cornell in 1943 and has since been assistant professor of metallurgy at the University of Oklahoma.

Dr. Dorothea Franzen, for the past year a member of the biology staff at Cedar Crest College, Allentown, Pa., has resigned her position to accept an appointment on the staff at Washburn Municipal University, Topeka. Dr. Franzen will begin her duties at Washburn in September.

Dr. F. A. Rohrman, head of the department of chemical engineering at Kansas State College, Manhattan, has resigned his position to become executive director of the engineering experiment station at the University of Colorado, Boulder. Dr. Rohrman will begin his new duties on July 1.

Mr. Charles A. Reynolds, who will receive his doctorate from Leland Stanford University this summer, has been appointed assistant professor of chemistry at the University of Kansas. Mr. Reynolds takes the place of Dr. David Hume who has resigned his position at Kansas to accept an appointment as assistant professor of analytical chemistry at the Massachusetts Institute of Technology.

Dr. N. H. Pronko, formerly of the College of the City of New York, and Professor J. W. Bowles of the Wichita Guidance Center and a graduate of the University of Indiana, have been added to the staff of the psychology department, University of Wichita, with appointments effective in September.

We regret to announce the death of Dr. Waldo E. Grimes, a member of the Academy, on May 23, 1947. Dr. Grimes was for over twenty-five years head of the department of economics and sociology at Kansas State College, Manhattan, and last year was honored at a special dinner in recognition of 25 years of service to Kansas. His outstanding work on freight rates was praised at that time by Governor Andrew Schoeppel.

Mr. H. Leo Brown, a frequent contributor to these *Transactions,* has been transferred by the U. S. Soil Conservation Service from Jewell Countv to Clark County, with headquarters at Ashland. Mr. Brown began his work in Clark County on June 2.

Dr. Donald C. Brodie, associate professor of pharmacy, and Dr. Albert C. Spalding, assistant professor of anthropology, University of Kansas, have resigned

their positions. Dr. Brodie becomes a member of the pharmacy college staff of the University of California at San Francisco and Dr. Spalding joins the staff of the University of Michigan, Ann Arbor.

The proved minable coal reserves of Kansas amount to nearly one billion tons, according to a report just issued by the State Geological Survey at the University of Kansas. This report, *Coal Reserves in Kansas,* lists and briefly describes each of the many coal beds of the state and points out that the potential reserves in the state total more than 17 billion tons. Both proved and potential reserves are given by counties and by coal beds. G. E. Abernathy, J. M. Jewett, and W. H. Schoewe prepared the report.

Coal ranks fourth in terms of annual dollar value among the Kansas minerals. Mining is now under way or has been active in the past in many counties in the eastern third of the State. Proved reserves are given for Atchison, Bourbon, Brown, Chautauqua, Cherokee, Coffey, Cowley, Crawford, Doniphan, Douglas, Elk, Franklin, Jackson, Jefferson, Labette, Leavenworth, Linn, Lyon, Montgomery, Nemaha, Neosho, Osage, Shawnee, Wabaunsee, Wilson, and Woodson Counties. Potential reserves are listed for each of the above, and in addition, for Greenwood, Miami, and Pottawatomie Counties.

Copies of the report can be obtained free of charge at the offices of the State Geological Survey in Lawrence or Pittsburg, or by mail for a mailing charge of 10 cents. It is Bulletin 70, part 1.

Dr. F. C. Gates, Kansas State College, Manhattan, has joined the staff of the University of Michigan Biological Station, Cheboygan, Michigan, where he will, as he has for many years past, teach courses in plant ecology.

Mr. Travis Brooks will join the staff of the department of botany and plant pathology at Kansas State College, Manhattan, in the fall. Mr. Brooks will work particularly in the field of mycology.

Dr. Clair A. Hannum has been appointed associate professor of zoology at the University of Wichita.

Professor Margaret Newcomb, Kansas State College, Manhattan, has returned to the University of Indiana this summer where she will continue her studies of Oenothera.

The Institute of Logopedics, University of Wichita, has recently received additions to its research equipment and library and now has one of the most complete libraries concerning speech pathology and speech correction in the United States. Individuals interested in speech problems are cordially invited to use the facilities of the Institute.

David M. Gates, who finishes his work this summer for the doctorate at the University of Michigan, has accepted an ap-

pointment to the staff of the University of Denver next fall.

Dr. Edwin O. Stene of the bureau of governmental research, University of Kansas, has returned to the University after spending the past semester at Harvard University in a postdoctoral fellowship in human relations.

During June and July the State Geological Survey will make magnetic surveys in Crawford County and radioactive surveys in Cherokee County. The preparation of a detailed magnetic map, it is hoped, will aid in finding new mineral deposits. Small amounts of radioactive elements are associated with metallic ores and the location of the source of such radioactive material is of aid in prospecting for new deposits of zinc and lead in the tri-state area. The surveys in both Crawford and Cherokee Counties will be under the direction of Dr. Robert M. Dreyer, geophysicist for the State Geological Survey.

The State Geological Survey reports an unusual area of igneous rock in Riley County, Kansas, near Bala. This rock, while hot and liquid, forced its way upward through the more familiar limestones, shales, and sandstones of central Kansas. A magnetometer survey of this extrusion has recently been made and is reported in Bulletin 70, Part 2. It can be obtained for a mailing charge of 10 cents by addressing the State Geological Survey, Lawrence.

Dr. Rufus Thompson, a member of the U. S. Biological Survey, Darlington, Md., has been added to the staff of the botany department, University of Kansas, beginning with the fall semester. Dr. Thompson, a graduate of the University in the class of 1936, received his doctorate from Leland Stanford University.

Dr. Donald S. Farnar, for the past two years assistant professor of zoology at the University of Kansas, has resigned his position to accept a similar one at the University of Colorado, Boulder.

Dr. Ivan L. Boyd, professor of biology at Baker University, Baldwin, is spending part of the summer at the University of Minnesota attending an educational work shop of the North Central Association of Colleges. Other Kansans in attendance are Dean Kloepffer of the College of Emporia and Miss Ruth Stout of Washburn Municipal University.

Dr. Joseph H. Burckhalter has been appointed associate professor of pharmaceutical chemistry at the University of Kansas effective next fall. Dr. Burckhalter, a graduate of the University of South Carolina, received his doctorate from the University of Michigan. At present he is coordinator of research in synthetic antimalarial drugs for Parke-Davis and Company.

Recent research grants awarded departments at Kansas State College, Manhattan, include the two described below:

Milling companies in Kansas,

Missouri, Minnesota, and Illinois have made a grant of $15,000 to the department of milling industry. This money will be for construction of a new pilot baking plant, which will have a capacity equal to that of most small town bakeries. It will enable students to acquire practical experience in operating commercial baking equipment, and will make possible research with flour and dough in quantities used in commercial work.

The department of botany and plant pathology has been granted $15,000 by Sharples Chemicals Inc. for the purpose of studying the effects of chemical compounds on certain phases of plant growth. James C. Bates, associate professor of botany, is carrying on experiments with horticultural plants such as tomatoes, potatoes, beans, and flowers. Howard W. Smith, assistant professor of entomology and plant pathology, is working with insecticides, fungicides, and soil fumigants.

Dr. Phillip S. Riggs, professor of physics and astronomy at Washburn University since 1939, has resigned his position at Washburn to become head of the astronomy department at Drake University, Des Moines. Dr. Riggs leaves Washburn at the end of the summer term.

Dr. Walter Kollmorgen of the department of geography, University of Kansas, has been promoted from associate professor to professorial rank.

ALAS, MR. BOYLE, "CHYMISTS" STILL STUN THEM!

If judicious men, skilled in chymical affairs, shall once agree to write clearly and plainly of them, and thereby keep men from being stunned . . . or imposed upon by dark and empty words; it is to be hoped, that these [other] men finding that they can no longer write impertinently and absurdly, without being laughed at for doing so, will be reduced to write nothing, or books that teach us something, and not rob men, as formerly, of invaluable time; and so ceasing to trouble the world with riddles or impertinencies, we shall either by their books receive an advantage, or by their silence escape an inconvenience.—Robert Boyle, *The Sceptical Chymist*, 1678.

Coaction of Jack Rabbit, Cottontail, and Vegetation in a Mixed Prairie*

H. LEO BROWN
Soil Conservation Service, U.S.D.A., Ashland.

INTRODUCTION

The native prairie is one of the greatest natural resources in the Great Plains. In fact range land often furnishes a major portion of the farm income. How to keep ranges at a continuous maximum production and how to bring them back to this condition when they have deteriorated, are problems that confront most livestock producers in this region. Native prairie animals are doubtless important in maintaining the prairies in a climax condition.

Research has furnished much information concerning the life history of most native prairie animals. But information concerning the extent to which the different prairie plants furnish food for native prairie animals is incomplete, also the part played by these animals in maintaining or regenerating the range is not fully known.

In western Kansas several grasses appear early when natural revegetation is allowed to occur on barren areas. Among the first are sand dropseed, Texas crabgrass, and windmill grass. Just how these grasses make their entrance so quickly is not fully known.

The present study is concerned with the activity of the jack rabbit (*Lepus californicus melanotis* Mearns) and the cotton tail (*Sylvilagus floridanus mearnsi* Allen) in relation to the utilization and dissemination of native plants in a mixed prairie near Hays, Kansas.

RELATED STUDIES

The mixed prairie was first identified as a distinct plant association by Clements (1920), who described its nature and range, also the grouping of dominants. Albertson (1937) segregated the mixed prairie near Hays, Kansas, into three types. The big bluestem dominated the ungrazed lowlands and ravines. Little bluestem and its associates were most common on the hillsides, while the short grasses occupied the high level land. The growth and seed yields of native prairie plants near Hays, Kansas, were studied by Brown (1942). Sand dropseed produced 172, 87, and 163 pounds of seed per acre, respectively, during the years of 1939, 1940, and 1941 on land being revegetated naturally.

Transactions Kansas Academy of Science, Vol. 50, No. 1, 1947.

*A thesis submitted to the Graduate Division of the Fort Hays Kansas State College in partial fulfillment of the requirements for the degree of Master of Science.

The effect of jack rabbits on the rate of recovery of deteriorated range land in New Mexico was studied by Parker (1938). He found that jack rabbits may consume as much as 99.4 per cent of the foliage of perennial grasses, and that it was inadvisable to attempt artificial reseeding of similar range land to grasses or palatable forbs without accompanying efforts to eradicate or control the rodents and rabbits.

Vorhies and Taylor (1933) made a study of the life history and ecology of jack rabbits in Arizona. They found that fifteen jack rabbits would consume as much forage as one sheep and that seventy-four jack rabbits would eat as much as one mature cow. Hendrickson (1929) of Iowa found that .55 and .52 pellets per square foot represent about one jack rabbit and one cottontail, respectively, per acre. The same author (1938) found that small trees and shrubs made up a large portion of the winter diet of the cottontail. Pellet counts indicated that the heaviest population of cottontails was in apple orchards with prunings and mown red clover or in apple orchards with prunings and winter rye.

Timmons (1942) observed the jack rabbits eating prickly pear cactus fruits in west-central Kansas and disseminating the seed in their fecal pellets. Germination of the seeds found in jack rabbit droppings was 62 per cent in comparison to 44 per cent in hand picked seeds. Extensive eating of cactus pads and prickly pear fruit by rabbits was reported by Riegel (1941, 1942) during the fall and winter of 1939, 1940, and 1941 near Hays. Most of the seeds eaten passed unharmed through the digestive tracts of the rabbits. During adverse conditions the remnants of several plant species were observed being used as food.

Studies on the effect of drought on animal population in western Kansas were made by Wooster (1935 and 1939). Jack rabbits increased greatly during the drought but during wet years their numbers were greatly reduced.

Weaver and Flory (1934) made a study of climax prairie and some environmental changes resulting from breaking the sod. Increase of rabbit population on overgrazed as compared with stabilized areas, and a similar change in the abundance of spermophiles could be cited as examples or a disturbed natural balance. Rabbits and rodents very much preferred the more succulent forbs that were so plentiful in disturbed areas.

The relation of jack rabbits to grazing in southern Arizona was studied by Taylor, Vorhies, and Lister (1935). Indications were

that rabbits preferred grazed areas to areas under total protection, or to those lightly grazed.

Taylor (1944) reports from eastern Texas that up to a certain point jack rabbits benefit from livestock grazing, tending to be scarce or absent when thick herbage, whether grass or forbs, covers the ground and obstructs their vision. Thus as the amount of vegetation is reduced by overgrazing the number of jack rabbits tends to increase and the cottontails tend to decrease.

LOCATION AND VEGETATION

The areas selected in this investigation contain approximately 550 acres in or near the college pasture about 2.5 miles west of Hays, Kansas. The pasture comprises about 405 acres, of which 129 acres are short grass, 152 acres are little bluestem and its associates, and 44 acres are lowland. In 1920, eighty acres were abandoned as farm land and fenced in with the college pasture where natural revegetation occurred. Bordering this pasture is an area of 36.5 acres of ungrazed little bluestem, one of 54 acres of land artificially reseeded to grass in 1941, and another area of 54.5 acres of winter wheat.

Due to the fact that since 1941 (except 1943) precipitation was considerably above normal, a luxuriant growth of vegetation occurred on most of the areas during the period of study.

The vegetation varied in the number of forbs in relation to the amount of native grasses. Weeds and occasional shrubs were present on some of the plant types. The basal cover and species present on the grass types were determined by charting 6 to 13 meter quadrats on each area. The plants found to be of greatest value to the rabbits on the area are given in Table 1.

Table 1.—Grasses, forbs, and shrubs utilized by the jack rabbit and cottontail.

Common Name	*Scientific Name*
Grasses	
Big bluestem	*Andropogon furcatus* Muhl.
Blue grama	*Bouteloua gracilis* (H. B. K.) Lag.
Buffalo grass	*Buchloe dactyloides* (Nutt.) Engelm.
Green foxtail	*Setaria viridis* (L.) Beauv.
Hairy dropseed	*Sporobolus pilosus* Vasey
Heavy sedge	*Carex gravida* Bailey
Hooker's dropseed	*Sporobolus hookeri* (Trin.) Vasey
Little bluestem	*Andropogon scoparius* Michx.
Sand dropseed	*Sporobolus cryptandrus* (Torr.) A. Gray
Side-oats grama	*Bouteloua curtipendula* (Michx.) Torr.
Stinkgrass	*Eragrostis-cilianensis* (All.) Link
Switch grass	*Panicum virgatum* L.
Western wheat grass	*Agropyron smithii* Rydb.

Forbs and Weeds	
Annual sunflower	*Helianthus annuus* L.
Blazing star	*Liatris punctata* Hook.
Broom weed	*Gutierrezia sarothrae* (Pursh) Britton and Rusby
Cactus	*Opuntia macrorrhiza* Engelm.
Chalk lily	*Nuttallia decapetala* (Pursh) Greene
Ground cherry	*Physalis lanceolata* Michx.
Houstonia	*Houstonia angustifolia* Michx.
Lead plant	*Amorpha canescens* Pursh
Low townsendia	*Townsendia exscapa* (Richards) Porter
Maxmilian sunflower	*Helianthus maximiliani* Schrad.
Many-flowered aster	*Aster multiflorus* Ait.
Perennial ragweed	*Ambrosia psilostachya* DC.
Prairie alfalfa	*Psoralea tenuiflora* Pursh
Prairie coneflower	*Ratibida columnaris* (Sims.) D. Don.
Prairie pansy	*Viola rafinesquii* Greene.
Purple poppy-mallow	*Callirrhoe involucrata* (T. and G.) A. Gray
Rayless thelesperma	*Thelesperma gracile* (Torr.) A. Gray
Redroot pigweed	*Amaranthus retroflexus* L.
Russian thistle	*Salsola pestifer* A. Nels.
Skull cap	*Scutellaria resinosa* Torr.
Soapweed	*Yucca glauca* Nutt.
Spiny sideranthus	*Sideranthus spinulosus* (Pursh) Sweet
Tetraneuris	*Tetraneuris stenophylla* Rydb.
Texas sandwort	*Arenaria texana* Britton
Velvety goldenrod	*Solidago mollis* Bartl.
Whitlow wort	*Paronychia jamesii* T. and G.
Yellow oxalis	*Oxalis stricta* L.
Shrubs	
Buckbrush	*Symphoricarpos orbiculatus* Moench.
Chokecherry	*Prunus melanocarpa* (A. Nels.) Rydb.
Ill-scented sumac	*Rhus trilobata* Nutt.
Prairie rose	*Rosa suffulta* Greene.
Smooth sumac	*Rhus glabra* L.

Short Grass

The short grass (*Buchloe-Bouteloua*) type was in a moderately grazed pasture and found widely distributed over the nearly level uplands (Fig. 1). Smaller areas of the short grasses also occurred at the base of the hills, particularly on south-facing slopes. A continuous cover of short grasses overtopped by scattered bunches of mid grasses often occurred in favorable places such as buffalo wallows.

Little Bluestem

The grazed little bluestem type was the most extensive in area and also had the largest number of species of forbs. The area occupied the hillsides and extended across the shallow ravines, also over the brows of the hills and far beyond where the slopes continued, but gave way to the short grasses on the level upland (Fig. 2). The presence of closely grazed mid grasses, together with blue grama and other short grasses, created an appearance of an unusually large amount of the shorter type of vegetation with scattered clumps of unmolested vegetation.

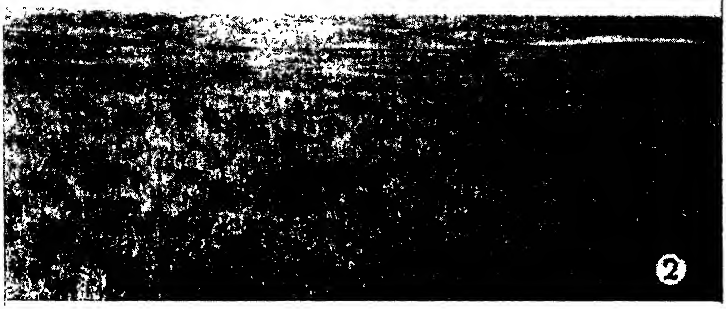


Fig. 1.—A short grass habitat with a dense cover of blue grama and buffalo grass and scattered plants of broomweed.

Fig. 2.—An area of lightly grazed little bluestem and its associates, of which side-oats grama, blue grama and hairy grama are most common.

Fig. 3.—Ungrazed little bluestem, uniformly clothed with mid grasses thereby reducing the cover of the short species

Ungrazed little bluestem, not having been utilized by livestock, was more uniformly clothed with mid grasses, thereby reducing the amount of the shorter species, especially at the base of the slopes (Fig. 3). A total of 25 species of grasses and 59 of forbs and shrubs were found on this area.

Lowland

Buffalo grass, side-oats grama, and blue grama were the dominant species due to moderate or heavy grazing by livestock during drought (Fig. 4). In some places western wheat grass formed a nearly pure stand, while in others an open stand overtopped a lower story of short grasses. Big bluestem, usually the dominant species on the ungrazed lowland type, remained only as remnants of the original cover.

Natural Revegetation

In 1920, eighty acres of cultivated land were abandoned and fenced in with the college pasture (Fig. 5). There were 9 species of grasses and 17 species of forbs and weeds found growing on this area. Sand dropseed had only a small basal cover but the high spreading foliage gave the appearance of a uniform cover over most of the area with islands of buffalo grass scattered throughout.

Artificial Revegetation

Cultivation on this area was discontinued in 1933, and in the spring of 1941 about 54 acres were seeded to native grasses (Fig. 6). Even though the basal cover was somewhat less than in native short grass, the accumulated debris was so heavy that scarcely any soil was exposed. The dead material from previous years' growth was 2 to 3 inches deep.

Wheat Field

The wheat field included in the study had been continuously cropped to wheat for several years and was used in this study primarily to compare the activity and populations of jack rabbits and cottontails on this area with those on the native prairie.

METHODS OF STUDY

Studies were begun early in the fall of 1944 on the areas selected for this purpose. The study was conducted to determine (1) abundance of fecal pellets, (2) rabbit population, (3) quantity of seeds per acre in pellets, (4) per cent germination of seeds found in pellets and those collected by hand, and (5) the number of seedlings growing from pellets. When recently deposited fecal pellets were found near partly eaten vegetation, it was assumed that these plants were utilized by the animals that deposited the pellets. Further

Fig. 4. A lowland habitat of big bluestem and wheat grass with blue grama and buffalo grass forming a lower story of vegetation.

Fig. 5.—Natural revegetation with a sparse stand of buffalo grass overtopped by sand dropseed and perennial ragweed.

Fig. 6.—An area reseeded to blue grama in 1941. Heavy growth in previous years has resulted in an abundance of litter.

evidence was gained by opening the pellets in order to identify their contents.

Abundance of Fecal Pellets

Pellet counts were conducted on each habitat from October, 1944, to March, 1945, inclusive, to estimate relative numbers and activity of rabbits under various ecological conditions. Pellets were also collected and tests were made to determine whether they contained viable seeds.

Rabbit Population

Line counts were made by using two cars spaced approximately 75 feet apart with a wire dragged between them to flush the rabbits. These counts were used in correlation with the fecal pellet counts taken each month on the plant habitats to get an index of the number of rabbits per acre on the basis of the number of pellets to the square foot.

Quantity of Seeds Per Acre in Jack Rabbit Pellets

All pellets on an area of 30 square feet in the natural revegetation and grazed little bluestem types were gathered each month. They were the basis on which to estimate the amount of seed of sand dropseed grass per acre contained in pellets.

Per Cent Germination of Seeds

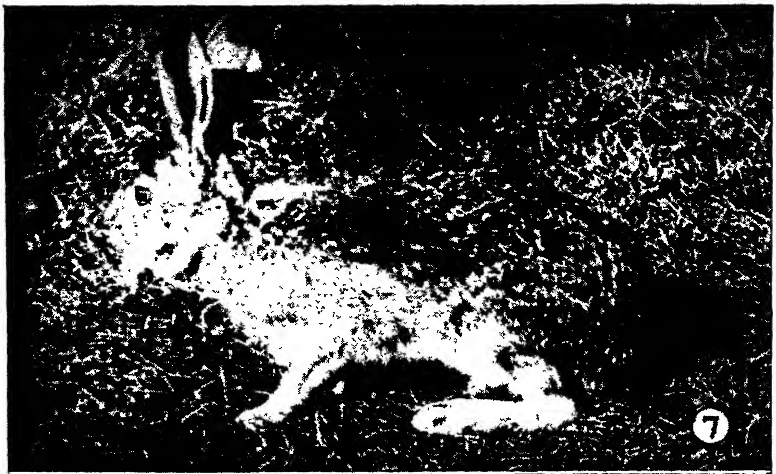
Germination tests were made to determine the viability of seeds found in pellets of rabbits in comparison to those not exposed to such conditions. The seeds were tested in petri dishes and also in sterilized soil. Those placed in the petri dishes were not exposed to the freezing and thawing temperature, whereas those tested in soil were planted in flats and placed outside where the seeds were exposed to the same weather conditions as were the seeds in the prairie.

RESULTS

The Jack Rabbit

Activity of the jack rabbit was observed on all habitats (Fig. 7). A total of 34 different species of plants on all habitats was found to furnish some food for this animal. Several species of plants were severely browsed while others were utilized very lightly. Greatest activity occurred on the grazed little bluestem type where 8 species of grasses and 15 of forbs were used as food by the rabbits. The plants on the remaining habitats were utilized to some extent, but only a few species were eaten in noticeable amounts.

The plants most heavily utilized were broomweed, soapweed, cactus, chalk lily, heavy sedge, sand dropseed, western wheat grass, blue grama, and buffalo grass. Broomweed was heavily eaten during



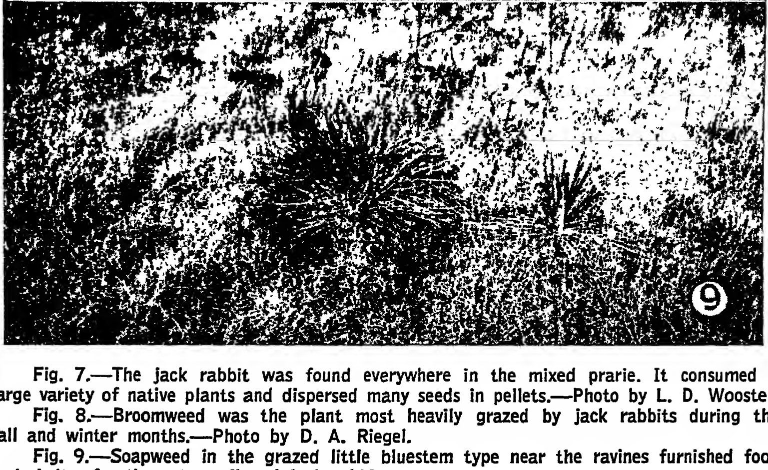


Fig. 7.—The jack rabbit was found everywhere in the mixed prarie. It consumed a large variety of native plants and dispersed many seeds in pellets.—Photo by L. D. Wooster.

Fig. 8.—Broomweed was the plant most heavily grazed by jack rabbits during the fall and winter months.—Photo by D. A. Riegel.

Fig. 9.—Soapweed in the grazed little bluestem type near the ravines furnished food and shelter for the cottontail and jack rabbit.

the fall and winter on all areas in which it was found (Fig. 8). The part of the plant usually consumed was a small portion of the stem below the branches of the flower stalk. The long needle-like leaves of the soapweed were heavily grazed during the winter months and in some instances the plants were entirely defoliated. Cactus, though very scarce, was eaten profusely and by late November the fruits had been completely devoured, but the pads provided a portion of the rabbits' diet throughout the winter months. The upper portions of the tap roots and the leaves of seedlings of the chalk lily were heavily utilized after the first damaging frost in the fall.

The green leaves of western wheat grass and heavy sedge were utilized within 2 to 3 inches of the ground throughout the period of study, whereas the leaves and leaf sheaths surrounding the inflorescence of sand dropseed were most commonly eaten. Blue grama and buffalo were utilized lightly and on several occasions rabbits dug beneath the snow and fed on the green growth in the crowns of these grasses.

For 3 days after a 4 to 6-inch snow Russian thistle and tetraneuris were extensively used as emergency food. A wheat field was utilized considerably in local areas during the fall and winter where rabbits often dug beneath the snow to feed on the green wheat. It was evident that jack rabbits preferred grazed areas with scattered clumps of taller vegetation. These areas furnished a variety of succulent herbage and a quick escape, while the scattered clumps provided a comfortable place to hide and rest.

In correlating the line counts and pellet counts taken on the various areas, it was ascertained that .54 pellets per square foot indicated approximately one jack rabbit per acre. According to number of pellets found, the jack rabbit was most abundant on the moderately grazed little bluestem type. The number per square foot on this type was .64, .58, and .60, respectively, for October, November, and December; but it decreased to .19, .21, and .12 for January, February, and March (Table 2). The rabbits apparently shifted their activity during the winter to a nearby wheat field where the pellet counts were .09, .19, and .22, respectively, for October, November, and December; but they increased to .50, .38, and .32 for January, February, and March.

The number of pellets was greater on the border between the grazed little bluestem and artificial revegetation than it was on the short grass and lowland areas. The natural revegetation had a fairly

high pellet count during autumn as compared to most of the other types, but dropped abruptly in December due to a prairie fire.

Table 2.—Average number of jack rabbit pellets per square foot on different plant types and the border between artificial revegetation and grazed little bluestem.

Type	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Artificial revegetation	.26	.16	.21	.06	.0	.0
Natural revegetation	.43	.25	Fire	.08	.05	.16
Short grass	.18	.10	.05	.05	.0	.03
Lowland	.12	.25	.19	.0	.01	.27
Grazed little bluestem	.64	.58	.60	.19	.21	.16
Ungrazed little bluestem	.26	.10	.17	.0	.0	.0
Wheat field	.09	.19	.22	.50	.38	.32
Border	.39	.43	.47	.22	.19	.26

Number of Seeds Found in Pellets

Numerous seeds of several plants were found in the fecal pellets of jack rabbits. Sand dropseed made up 93 per cent of the seeds found on all plant types, while redroot pigweed, buffalo grass, cactus, ground cherry, Hooker's dropseed, and prairie pansy constituted the remaining 7 per cent. Seeds were most numerous when taken from pellets deposited in October and November.

Approximately 65.5 per cent of the pellets collected on the natural revegetation area contained seeds. The average was 111.2 seeds per pellet with some which were collected in October running as high as 574 (Table 3). On the artificial revegetation type 46.5 per cent of the pellets taken had seeds and the average was 4.9 seeds per pellet. Of the pellets taken on the short grass type, 57.9 per cent contained seeds, averaging 7.5 per pellet. The per cent of seed-bearing pellets collected on the lowland, grazed little bluestem, ungrazed little bluestem, and the wheat field was 56.2, 33.3, 7.8, and 29.0, respectively. The average number of seeds per pellet in the same order was 3.2, 2.7, .2, and 1.7.

Table 3.—Data on jack rabbit pellets collected on various plant types.

Habitat	No. of pellets collected	No. of pellets with seed	Per cent pellets with seed	Average No. of seeds per pellet
Natural revegetation	242	159	65.5	111.2
Artificial revegetation	200	97	46.5	4.9
Short grass	190	110	57.9	7.5
Lowland	178	100	56.2	3.2
Grazed little bluestem	381	127	33.3	2.7
Ungrazed little bluestem	77	6	7.8	.2
Wheat field	258	76	29.0	1.7

Quantity of Seeds in Pellets

In October an average of 179 pellets was found on an area of 30 square feet of natural revegetation (Table 4). The pellets in this type contained an average of 197 seeds per pellet, of which 179 were sand dropseed. On the basis of the above figures, the pellets from an area of 30 square feet contained 32,041 seeds of sand dropseed. The seeds of this grass deposited in pellets over an acre of

natural revegetation would amount to 46,523,532. The number of seeds per pound was determined by carefully separating 6 samples of 1 gram each and counting the number of seeds in each gram. There was an average of 13,225 seeds per gram. By multiplying this number of grams per pound (13,225 x 454) the number of seeds per pound (6,004,150) was ascertained. From these data it was found that in October approximately 7.7 pounds of seeds per acre were deposited in jack rabbit pellets on the natural revegetation type. For the corresponding month on grazed little bluestem the average number of seeds was 2.7 in each of the 215 pellets collected on the 30 square feet. Following the calculations as above, it was found that about 2 ounces of seed per acre were deposited in pellets on this plant type during October.

The number of pounds of seed of sand dropseed deposited during the six months (October to March) was approximately 12.75 and .5, respectively, for the natural revegetation and the grazed little bluestem types. The big decrease in number of seeds deposited in pellets in December and thereafter on the natural revegetation was doubtless due to the fire in late November that destroyed all the vegetation.

Table 4.—Number of jack rabbit pellets collected on an area of 30 sq. ft.

Habitat	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
Natural revegetation	179	164	72	74	114	130	733
Grazed little bluestem	215	200	171	131	137	142	996

Germination of Seeds

The viability of seeds germinated in petri dishes was less (except buffalo grass) than when the seeds were tested in soil. Buffalo grass seeds taken from pellets tested in petri dishes were 100 per cent viable but only 57.5 per cent when hand picked. The soil tested seeds showed 90 per cent germination from pellet borne seeds and 36.5 per cent from hand collected ones. No signs of germination were found in cactus seeds in the petri dish test. In the soil test, however, 57 per cent germinated from seeds taken from pellets and 42 per cent from hand gathered seeds. The percentage of viable seeds taken from pellets tested in petri dishes for sand dropseed, Hooker's dropseed, and redroot pigweed was, respectively, 4.2, 20.0, and 18.4 and in the hand picked seeds it was 3, 14, and 24. In the soil tested seeds taken from pellets in the same order it was 31.3, 40.0, and 10.0 and for the hand gathered seeds 42, 70, and 77 per cent. Only seeds of the prairie pansy and ground cherry collected from pellets were available for germination. The per cent germina-

tion was nil for the seeds of both species when tested in the petri dish, but when tested in soil it was 25.9 and 60.0 per cent respectively.

The Cottontail

Utilization by cottontails was observed on a total of 32 different species of plants. Most of these plants were on the ungrazed little bluestem type where 7 species of grass, 12 of forbs, and 2 of shrubs were partly eaten. Extensive plant foraging was found on the border of the grazed little bluestem near the lowland where 3 species of grass, 9 of forbs, and 4 of shrubs were partly consumed.

The vegetation most generally utilized was various species of shrubs. Prairie rose, chokecherry, smooth sumac, and ill-scented sumac often were badly barked or browsed to within 2 to 5 inches of the ground. The leaves of western wheat grass and sand dropseed were grazed in appreciable amounts on all plant types. The leaves and stems of heavy sedge and broom weed were eaten in small quantities on areas in which they were found. Leaves of soapweed were consumed in small amounts and the plant served as protection for the cottontails (Fig. 9).

It was found by correlating the line count and pellet count that .5 pellets per square foot indicated about one cottontail to the acre.

According to pellet counts the cottontails were most numerous on the lowland and ungrazed little bluestem types (Table 5). The number of pellets per square foot on the lowland type was .97, .72, and .89 for October, November, and December, respectively, and .36, .46, and .55 on the little bluestem type for the same months. The numbers decreased on the lowland for January, February, and March when it was .2, .15, and .15, while it increased on the ungrazed little bluestem to .57, .46, and .5. The concentration of pellets on the artificial revegetation along the border between this type and the grazed little bluestem was slightly lower than on the above mentioned types. The natural revegetation, short grass, and wheat field showed small pellet counts.

Table 5.—Average number of cottontail pellets per square foot on different plant types and border between artificial revegetation and grazed little bluestem.

Type	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Artificial revegetation	.74	.46	.30	.18	.08	.10
Natural revegetation	.0	.0	.0	.0	.15	.18
Short grass	.0	.0	.15	.21	.10	.05
Lowland	.97	.72	.89	.20	.15	.15
Grazed little bluestem	.26	.30	.30	.17	.08	.06
Ungrazed little bluestem	.36	.46	.55	.57	.46	.50
Wheat field	.02	.04	.07	.0	.0	.0
Border	.46	.55	.30	.28	.15	.10

Number and Species of Seeds in Pellets

On the natural revegetation area 39.7 per cent of the pellets col-

lected contained seeds with an average of 1.16 seeds of sand dropseed per pellet (Table 6). On the artificial revegetation type, 29.1 per cent of the pellets contained seeds averaging .67 per pellet. The number of pellets containing seeds was relatively low on the grazed and ungrazed little bluestem types, and the average number of seeds per pellet was less than one.

Table 6.—Record of cottontail pellets collected on various plant types.

Habitat	No. of pellets collected	No. of pellets with seed	Per cent pellets with seed	Average No. of seeds per pellet
Artificial revegetation	271	79	29.1	.67
Natural revegetation	114	43	39.7	1.16
Short grass	147	14	9.5	.95
Lowland	356	14	3.9	.10
Grazed little bluestem	234	34	14.6	.98
Ungrazed little bluestem	255	44	15.2	.47

Pellets deposited in October, November, and December contained the largest amount of seeds, but the number was less in February and March. Sand dropseed comprised more than 99 per cent of the seeds found in pellets, the remainder being prairie rose and smooth sumac. As many as 34 seeds of sand dropseed were taken from one pellet collected in October on the natural revegetation type.

Germination of Seeds

Germination tests were made on sand dropseed, smooth sumac, and the prairie rose. Only sand dropseed was viable in both the petri dish and the soil germination test. When tested in petri dishes, 7 per cent of the seeds taken from pellets were viable but only 3 per cent of the hand picked seeds germinated, whereas the soil tested seeds had viability of 62.5 per cent for those collected from pellets and 42 per cent from the hand gathered seeds. Only soil tested seeds of sumac were viable. For seeds removed from pellets it was 32 per cent and for the hand collected seeds 19 per cent. The prairie rose failed to germinate in either of the methods.

Animals as Aids in Plant Dispersal

Seedlings were found growing from pellets deposited by jack rabbits and cottontails on several of the plant types. During the spring of 1945 as many as 32 seedlings of sand dropseed were found emerging from one jack rabbit pellet. On a reconnaissance survey, 47 jack rabbit pellets and 3 cottontail pellets, with seedlings of sand dropseed growing from them, were found on a wheat field or one of the revegetation types (Fig. 10). Twelve pellets of the jack rabbit were found containing seedlings of redroot pigweed and 2 others each with a buffalo grass seedling. Cactus seedlings were found growing from seed embedded in pellets of the jack rabbit (Fig. 11).

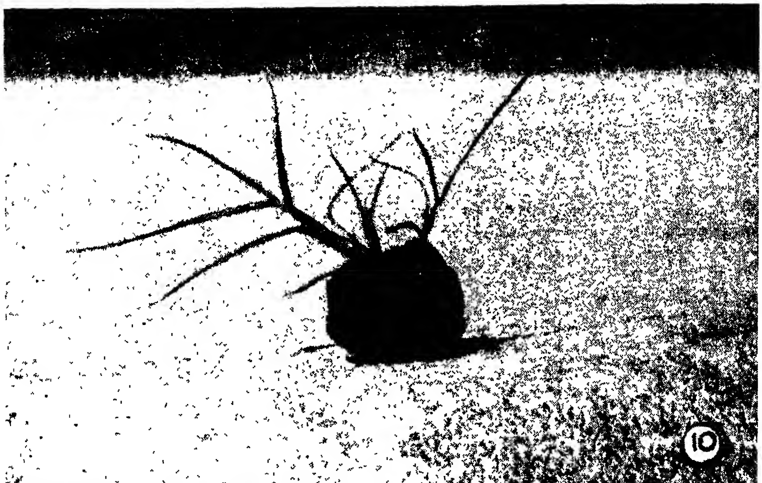


Fig. 10.—Seedlings of sand dropseed growing from jack rabbit pellets.

Fig. 11.—Cactus seedlings were often found growing from seed embedded in pellets of the jack rabbit.—Photo by D. A. Riegel.

SUMMARY

The utilization and dissemination of native plants by the jack rabbit and cottontail on a mixed prairie near Hays, Kansas, were studied. If recently deposited fecal pellets were found near plants partly eaten it was considered that these plants were utilized by the animal that deposited the pellets.

The jack rabbit was found to utilize a total of 34 species of plants. Even the cottontail secured food from 31 species but several

were of non-important woody plants such as smooth sumac, ill-scented sumac, chokecherry, and prairie rose.

Jack rabbits were most abundant on the grazed areas. This was perhaps due to the succulent herbage for food, the short turf for a quick escape, and the scattered bunches of vegetation to furnish protection. The cottontail preferred areas with a thick growth of the taller grasses and societies of weeds and shrubs accompanied with rocks and burrows for protection.

A close correlation was found between the number of pellets and the abundance of jack rabbits and cottontails frequenting an area. A count of .54 jack rabbit pellets per square foot represented approximately one jack rabbit per acre and .5 pellets per square foot indicated about one cottontail to an acre.

Seeds of several species of plants were taken from pellets of the jack rabbit and the cottontail. Germination tests showed that many of the seeds were viable and that passing through the digestive tracts of rabbits increased the germination of some of the seeds. This was especially true of buffalo grass, cactus, and smooth sumac whereas sand dropseed was affected but very little. The jack rabbit was more important than the cottontail in disseminating seeds in pellets. Approximately 12.75 pounds of seed of the sand dropseed were deposited in jack rabbit pellets on an acre in the natural re-vegetation type. This is considerably more than is recommended for reseeding abandoned cultivated fields.

It seems reasonable to assume from the preceding data that jack rabbits and cottontails are of considerable assistance in introducing seeds of prairie plants into abandoned cultivated fields and range land denuded by drought or overgrazing.

Literature Cited

Albertson, F. W. 1937. Ecology of mixed prairie in West-Central Kansas. Ecological Monographs 7: 481-547.

Arnold, J. F. and H. S. Reynolds. 1943. Droppings of Arizona and Antelope jack rabbits and the pellet census. Journal of Wildlife Management 7: 322-327.

Brown, H. Ray. 1943. Growth and seed yields of native prairie plants in various habitats of the mixed prairie. Transactions of the Kansas Academy of Science 46: 87-99.

Burnett, W. L. 1926. Jack rabbits of Eastern Colorado. Colo. Agr. College Cir. 52. 1-18.

Costello, David F. 1944. Natural revegetation of abandoned plowed land in the mixed prairie association of Northeastern Colorado. Ecology 25: 313-326.

Hendrickson, George O. 1938. Winter food and cover of Mearns cottontail. Third North American Wildlife Conference. 787-793.

———. 1939. Inventory methods for Mearns cottontail. Fourth North American Wildlife Conference. 209-215.

NELSON, EDWARD W. 1918. Smaller North American mammals. National Geographic Magazine 33: 371-493.

PARKER, K. W. 1938. Effects of jack rabbits on the rate of recovery of deteriodated range land. New Mexico Agr. Expt. Sta. Bull. 839: 1-3.

RIEGEL, D. A. 1941. Some coactions of rabbits and rodents with cactus. Trans. of the Kansas Academy of Science 44: 96-103.

————. 1942. Some observations of the food coactions of rabbits in Western Kansas during periods of stress. Trans. of the Kansas Academy of Science 45: 369-375.

TAYLOR, WALTER P. and W. G. MCGINNIS. 1928. The bio-ecology of forest and range. Scientific Monthly 27: 177-182.

TAYLOR, WALTER P., C. T. VORHIES and P. B. LISTER. 1935. The relation of jack rabbits to grazing in Southern Arizona. Jour. of Forestry 33: 490-498.

TIMMONS, F. L. 1942. The dissemination of prickley pear seed by jack rabbits. Jour. of the Amer. Soc. of Agron. 34: 513-520.

VORHIES, CHARLES T. and WALTER P. TAYLOR. 1933. The life history and ecology of jack rabbits, *Lepus alleni alleni* and *Lepus californicus ssp.*, in relation to grazing in Arizona. Univ. of Arizona Agri. Expt. Stat. Tech. Bull. 49: 471-574.

WEAVER, J. E. and EVAN L. FLORY. 1934. Stability of climax prairie and some environmental changes resulting from breaking. Ecology 15: 333-347.

WEBB, JOHN. 1940. Identification of rodents and rabbits by their fecal pellets. Tran. of the Kansas Acad. of Sci. 43: 479-481.

WOOSTER, L. D. 1935. Notes on the effect of drought on animal population in Western Kansas. Trans. of the Kansas Acad. of Sci. 38: 351-352.

Kansas Mycological Notes: 1946[1]

STUART M. PADY, E. D. HANSING, and C. O. JOHNSTON[2]
Agricultural Experiment Station, Manhattan.

Publication of miscellaneous notes and observations on the occurrence, distribution, severity, and importance of plant diseases, as well as similar notes on nonparasitic fungi in Kansas, was resumed for the year 1945. This constitutes the report covering the calendar year 1946. Herein are presented observations made by mycologists, plant pathologists, and others during travel made in all parts of the state and on disease specimens received for identification. A special effort is made to record pertinent facts regarding the plant diseases of major economic importance and the occurrence of diseases or fungi new to the state, or those assuming unusual importance.

1946 Weather as Related to Plant Diseases

Weather conditions in Kansas in 1946 seemed to indicate the beginning of a change from a period of moderate temperatures and abundant rain toward a period of higher temperatures and limited precipitation. For example, the fall of 1945, beginning in October, was extremely dry in the western third of the state, and this condition extended into 1946, so that by the end of February there had been a five-month period of the driest conditions since 1937-38.

Table 1 shows that, beginning with April, 1946, there was a deficiency in rainfall for the state as a whole in every month through August. There was a decided increase in temperatures accompanying the low precipitation, as shown in the last column in table 1. Temperatures were considerably above normal in the first half of the year in every month except May. By the end of July there was a cumulative excess of 28.2° F. This was due primarily to large excesses for each of the first four months. The winter of 1945-46 was extremely mild, and springlike weather occurred in most localities from mid-January onward. This resulted in one of the earliest springs on record. By April 1 it was estimated that spring growth of most plants was two to three weeks ahead of normal. May was cool and dry in most parts of the state except the western third where rains arrived in time to save a bumper wheat crop. June and July

Transactions Kansas Academy of Science, Vol. 50, No. 1, 1947.

[1]Contribution No. 486, serial No. 395, Dept. of Botany, Kansas Agricultural Experiment Station.

[2]Formerly Assoc. Professor, Assoc. Professor, Kansas Agr. Exp. Sta., and Pathologist, Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture.

were hot and dry in all sections and hot winds did much damage to growing crops, although winter wheat and oats were far enough advanced to escape major damage in most localities.

The variable weather conditions had a decided effect on the development of diseases of crop plants in all parts of the state. The long dry period in the fall in western counties prevented the development of volunteer cereals and greatly retarded emergence and growth of fall-sown cereals. The absence of lush growth early in the fall, combined with the absence of moisture in the form of rains and dews, prevented the development of leaf rust in the fall. As a consequence fall leaf rust infection in western Kansas was the lowest in several years, although it was fairly abundant in central and eastern counties. The mild winter permitted rather abundant overwintering of leaf rust in those counties and heavy infection developed on wheat in the eastern third of the state in May and June. It was light to almost absent elsewhere.

Table 1.—1946 Meteorological Data for Kansas showing means and deviations from the mean precipitation and temperature.[1]

	Precipitation in Inches					Temp. in degree F.	
	East Third	Central Third	West Third	State Mean	Deviation	Mean	Deviation
Jan.	2.47 (+)*	.98 (+)	1.24 (+)	1.24	+ .54	34.4	+4.4
Feb.	.95 (—)	.67 (—)	.70 (+)	.77	— .22	41.9	+8.5
Mar.	2.86 (+)	1.98 (+)	1.80 (+)	2.21	+ .74	52.5	+8.9
Apr.	3.06 (—)	1.27 (—)	.58 (—)	1.64	—1.04	60.4	+5.6
May	3.53 (—)	3.36 (—)	3.43 (+)	3.44	— .36	60.5	—3.3
June	4.27 (—)	2.54 (—)	2.68 (—)	3.16	— .86	75.8	+2.0
July	1.30 (—)	2.23 (—)	2.03 (—)	1.85	—1.27	81.3	+2.1
Aug.	4.17 (+)	2.80 (—)	1.94 (—)	2.97	— .21	77.8	—0.2
Sept.	4.27 (+)	3.80 (+)	2.90 (+)	3.66	+ .80	68.9	—0.8
Oct.	2.99 (+)	3.81 (+)	5.87 (+)	4.22	+2.23	58.4	+1.1
Nov.	2.34 (+)	2.99 (+)	3.05 (+)	2.56	+1.29	42.9	—0.4
Dec.	1.26 (—)	.42 (—)	.04 (—)	.57	— .32	38.7	+5.6

Sectio

*Symbols in parentheses refer to variations from the average monthly pr

The cool, dry weather during May and the very hot, dry weather of June were very unfavorable for the infection and development of stem rust on all cereals and for crown rust on oats. Except for occasional low wet spots stem rust was exceedingly rare on wheat in Kansas in 1946. Not since yearly records were established has there been an oat crop in Kansas so free from rust. Most fields had only the barest traces of infection of crown or stem rust, and in many fields it was impossible to find any rust infection. As a consequence, most oats remained standing long after maturity. The hot winds of June ripened all grains prematurely and there was no chance for rust infection to develop late in the growing season.

Observations on Cereal Rusts and Smuts

The foregoing discussion clearly indicates that 1946 was not a "rust year" in Kansas. Aside from leaf rust of wheat, which was

heavy in the eastern third of the state, all rusts of crop plants were unusually light. The following estimates on losses are presented merely as a matter of record:

Leaf rust of wheat (*Puccinia rubigo-vera tritici*)	2 per cent
Stem rust of wheat (*P. graminis tritici*)	present, no loss
Crown rust of oats (*P. coronata*)	present, no loss
Stem rust of oats (*P. graminis avenae*)	present, no loss
Leaf rust of barley (*P. hordei*)	present, no loss
Stem rust of barley (*P. graminis*)	present, no loss
Leaf rust of rye (*P. dispersa*)	trace
Stem rust of rye (*P. graminis secalis*)	present, no loss
Stem rust of timothy (*P. graminis phlei-pratensis*)	trace
Red clover rust (*Uromyces fallens*)	trace
Flax rust (*Melampsora lini*)	present, no loss

Leaf rust of wheat was the most abundant of the cereal rusts in 1946, and in some southeastern and south central counties it caused considerable loss. One interesting phase of leaf rust observations was the very heavy infections noted on Kawvale and Pawnee. When these varieties were distributed they usually exhibited striking resistance to leaf rust in the field. Neither variety exhibited much resistance in 1946 and in many fields they appeared completely susceptible. It is known that both varieties possess high resistance to physiologic race 9 but no resistance to race 126. Ten years ago race 126 was unknown in Kansas and race 9 constituted more than half of the physiologic race population in the state. Race 126 first appeared in 1940 and by 1946 constituted about 29 per cent of all isolates made from Kansas collections of leaf rust.

A bacterial infection of the uredia of *Puccinia graminis avenae* was observed in part of a plot of Neosho oats at the agronomy farm, Kansas Agricultural Experiment Station. The area in which the infection was noted was low and wet, and the crop was late, allowing infection to develop there; whereas in most of the field there was only a trace of rust. At the time of combining, the straw in the low area was still green. The bacteria were confined to the uredia on the stems and had developed to such an extent that the pale yellow slightly shiny exudate was clearly visible as hard dried droplets. The infected stems had a dull grayish color which was quite distinct from the normally infected stems. It was not determined whether the bacteria were parasitic upon the urediospores but bacterial masses in the uredia, along with the fact that all production of urediospores was completely checked whenever bacteria were present, strongly suggested a parasitic relationship.

In the mycological notes for 1945 reference was made to an infected barberry bush near Lebanon, Kansas, which bore abundant pycnia and aecia on practically all leaves, and which was subsequent-

ly identified as a rye race (*Puccinia graminis secalis*). At some time later in the season or during the winter, the barberries were cut off at the ground level. On May 23 M. E. Yount, associate pathologist, U. S. Department of Agriculture, reported that sprouts 18 to 24 inches high had grown up from the base and had leaves showing rust pycnia. Aecia were present by June 6. The general absence of stem rust of wheat (*Puccinia graminis tritici*) from Kansas would again suggest that the infection did not involve wheat in its cycle and was presumably a rye race. In the town of Lebanon two barberry hedges that had a few infected leaves in 1945 were entirely free from rust in 1946.

Bunt (*Tilletia foetida*) of wheat was more severe in Kansas in 1946 than during any year since 1937. The average estimated loss for the state due to this disease was 0.5 per cent. A few fields were reported in central and eastern Kansas with a loss of 75 per cent. Some of these fields yielded only 3 bushels per acre. Fields with a loss of 1 to 10 per cent were fairly common. Bunt was especially severe in Sedgwick, Sumner, Dickinson, and Geary counties. It was found principally in fields of the varieties of Red Chief, Chiefkan, and Clarkan. All fields of Pawnee and Comanche that were examined were free from bunt.

Loose smut (*Ustilago tritici*) of wheat caused an estimated loss of 2 per cent in 1946. The maximum infection observed was 26 per cent in a field of Clarkan wheat in Osage County. Loose smut was more prevalent in eastern than in central and Western Kansas. All of the fields of Pawnee surveyed were free from loose smut.

Smut (*Ustilago avenae* and *U. kolleri*) of oats caused an estimated loss of 3 per cent in 1946. The warm and moderately dry weather of February and March (table 1) was highly favorable for smut infection. The maximum per cent infection observed was 61 per cent in a field of Kanota in Sedgwick County. The average loss in Kansas in fields of Kanota and Fulton was 12 and 0.3 per cent, respectively. Fields of Osage, Neosho, Tama, and Vicland were free from smut.

Brown loose smut (*Ustilago nuda*), black loose smut (*U. nigra*), and covered smut (*U. hordei*) of barley caused estimated losses of 5, 4, and 1 per cent, respectively. Maximum infections were found of 36 per cent in a field of Beecher spring barley in Phillips County and 47 per cent in a field of Reno winter barley in Stafford County. High losses due to smut during the last few years have been a major factor in the decline in barley production in Kansas.

Helminthosporium Blight of Oats

Helminthosporium blight (*Helminthosporium victoriae*)[9] of oats was observed first at the Iowa and Arkansas agricultural experiment station in 1944. In 1946 it was observed and identified in Kansas. It was reported this year in most of the oat-growing states in central and eastern United States, from Texas to Idaho in the West, to Florida and New York along the Atlantic Coast.

It is believed that the fungus causing this new disease has occurred as a saprophyte or weak parasite on certain grasses, such as timothy, orchard grass, and green foxtail, for a long time; but our older varieties of oats were resistant; consequently, the disease did not build up.

The variety Victoria was introduced from South America in 1927. Since it was resistant to crown rust and smut, it has been used extensively in breeding new varieties of oats. In 1946, approximately 35,000,000 acres of new varieties with Victoria as one of their parents or grandparents were grown in the United States. These varieties are resistant to rust and smut and have added millions of bushels to the nation's oat crop since 1940 when they were first distributed. Unfortunately, however, all of these varieties are susceptible to this new disease, and the fungus has found a new host that is grown on millions of acres. Helminthosporium blight was the most destructive disease of oats in the United States in 1946 causing a loss of millions of bushels of grain. The estimated losses of "Victoria type" oats for a few of the states in central United States were: Texas, 10 per cent; Missouri, 12 per cent; Iowa, 25 per cent; Illinois, 20 per cent; and Indiana, 10 per cent.

Helminthosporium blight was of minor importance in Kansas in 1946, causing an estimated loss of two per cent in "Victoria type" oats. The highest loss was reported from a 10-acre field of Neosho oats in Douglas County (table 2). In this field there was 15 per cent lodging and an estimated loss of 35 per cent caused by this disease. Helminthosporium blight was observed and the fungus isolated from infected plants grown on experimental fields and on several farms in the state.

The observations that Helminthosporium blight was of minor importance in Kansas in 1946 are substantiated by yields obtained in 46 cooperative oat variety tests by A. L. Clapp, agronomist, Kansas Agricultural Experiment Station. In these tests Osage averaged 53.2 bushels per acre, Neosho 51.5, Fulton 49.5, Tama 48.3, and

[9]Meehan, Frances, and H. C. Murphy. A new Helminthosporium blight of oats. Science 104: 413-414. 1946.

Clinton 45.8. If Helminthosporium blight had been severe, the resistant variety Fulton would have yielded more than the susceptible varieties Osage and Neosho in 1946.

Table 2.—Effect of crop rotation on Helminthosporium blight of oats. Douglas County, 1946.*

Number Acres	Previous Crop	Per Cent Lodging	Yield Bushels Per Acre
10	Neosho Oats	15	30
25	Wheat	0	45
15	Lespedeza	0	50

*Soil fertility and other agronomic factors for yield on this farm were approximately equal.

Symptoms of the Disease. Helminthosporium blight may infect the oat plant from the time the seed germinates until it reaches maturity. Some seedlings die before they emerge, thus reducing the stand of plants. Infected seedlings that survive are streaked frequently with an orange to brownish color, especially along the edges

Figure 1.—Effect of Helminthosporium blight on oat plants in the field. Plant at left is healthy; remaining plants show different degrees of infection with Helminthosporium blight.

of the leaves. The plants are dwarfed, and most of the roots are brown or rotted off (Fig. 1).

Many of the plants shrivel and die before the heads are filled. The lower nodes are blackened and the internodes are brownish and translucent. The stems break over, often near the ground line and at the lower internodes. Lodging in oat fields is somewhat similar to lodging in wheat fields caused by Hessian fly. Severely infected fields in other states have lodged 100 per cent.

Varietal Susceptibility. The Kansas Agricultural Experiment Station recommends the oat varieties Kanota, Fulton, Osage, and Neosho. Kanota and Fulton are resistant to Helminthosporium blight (Fig. 2) but susceptible to rust and some races of smut. Osage and Neosho are susceptible to Helminthosporium blight but resistant to rust and smut. Among other varieties grown in Kansas Boone, Tama, Cedar, Vicland, and Fultex are susceptible to Helminthosporium blight, while Marion, Columbia, Red Texas, Early Bird, and Clinton are resistant.

Figure 2.—Reaction of seedlings of four oat varieties to Helminthosporium blight in naturally infested soil. From left to right, Kanota, Fulton, Osage, and Neosho. Note large number of dead seedlings in Osage and Neosho.

Seed Treatment and Crop Rotation. Helminthosporium blight is carried from one season to the next on the seed and in the soil. Experiments conducted in the greenhouse have shown that treating

infected seed with New Improved Ceresan at the rate of ½ ounce per bushel two days before planting in noninfested soil was effective in controlling the seedling blight stage of the disease (Fig. 3). New Improved Ceresan, however, was only partly effective in controlling the disease when the seed was planted in infested soil.

Crop rotation apparently is effective in reducing losses caused by Helminthosporium blight in Kansas. In 1946 three fields of Neosho oats were grown on a farm in Douglas County (table 2). In the 10-acre field where crop rotation was not followed there was 15 per cent lodging due to the disease and a yield of approximately 30 bushels per acre. In the other two fields there was no lodging and a yield of approximately 45 and 50 bushels per acre.

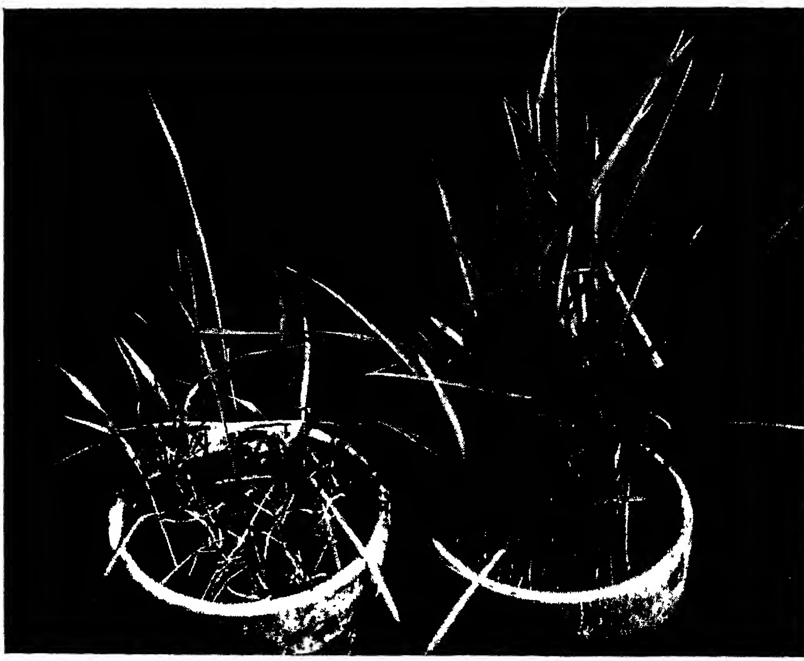


Figure 3.—Effect of treating infected seed of Tama oats with New Improved Ceresan on control of seedling blight. Left untreated; right treated.

The Kansas Agricultural Experiment Station and the United States Department of Agriculture are cooperating in breeding new varieties of oats for Kansas with combined high resistance to Helminthosporium blight, rust, and smut and with superior agronomic characteristics. It will be several years before any of these selec-

tions will be tested sufficiently to be distributed as recommended varieties.

Notes on Miscellaneous Plant Diseases

False stripe has been described as a physiologic leaf disease of barley. Among some of the barley varieties growing in the agronomy nursery, Kansas Agricultural Experiment Station, there appeared a necrosis of the leaves which resulted in a narrow elongated stripe, sometimes extending from one end of the blade to the other. In several cases the leaf became shredded and torn. The dead tissue at the center was light gray in color, and for the most part was free of any evidence of fungus activity. Material sent to Iowa State College, and to the Division of Cereal Crops and Diseases, U. S. Department of Agriculture, was identified as a physiological condition known as false stripe. This disease can be readily distinguished from stripe disease of barley (*Helminthosporium gramineum*) by the absence of fungal fructifications and by its localized effect upon the foliage. Net blotch (*Helminthosporium teres*) was also present on some of the leaves but damage was slight.

Flax rust (*Melampsora lini*) is uncommon in Kansas, but records indicate that a trace was present in 1921, and 1941. It was found in the latter year in the variety plots at the agronomy farm of the Kansas Agricultural Experiment Station at Manhattan. Flax is grown in the eastern third of the state, particularly in southeastern counties, but the rust may be said to be rare. The occurrence of very heavy infection in one field in Linn County indicates that the growing of susceptible varieties year after year may result, in a favorable year, in building up of the disease. Most of the leaves of the specimens received had been destroyed by heavy uredial infection, while the stems showed striking masses of black teliospores often with yellow urediospores in the center. Sectioning revealed abundant teliospores in typical subepidermal layers.

Red clover rust (*Uromyces fallens*) is ordinarily not abundant until the fall, but in 1946 it was found in abundance as early as June in eastern Kansas. In July fields of red clover in northeastern Kansas were examined and all showed uredial infections but only in certain fields could the rust be described as heavy. Powdery mildew (*Erysiphe polygoni*) also was present in some of the fields but only occasionally was it prominent. An unidentified leaf spot was present on some plants, causing small angular brown lesions sharply delimited by the veins.

Timothy is not extensively grown in Kansas, the few fields being confined to northeastern counties. In one field near Atchison,

Kansas, examined in July, stem rust (*Puccinia graminis phlei-pratensis*) was heavy on all green stems. Leaf spot (*Scolecotrichum graminis*) was causing extensive injury on the leaves of all plants.

The first record of Iris rust (*Puccinia iridis*) in Kansas was obtained from a specimen sent in June 10 from Leavenworth. It was found on a cultivated hybrid iris which had been grown there for many years. The ancestry of this susceptible hybrid was not learned, but in appearance it was related to *Iris versicolor*. Later the rust was collected on wild *I. versicolor* along the Missouri river.

Peony diseases were very prevalent in the vicinity of Manhattan, especially on nursery stock. One of the most prevalent caused large purple blotches on the leaves, which appeared to fit the description of leaf blotch (*Cladosporium paeoniae*). Associated with the leaf blotch was a stem-spotting condition commonly known as "measles" because of the numerous small red spots. The cause of this latter condition, according to Freeman Weiss, mycologist, U. S. Department of Agriculture, who examined the material, is obscure, although *Cladosporium* is generally considered to be the cause.

Brown spot on pine needles, caused by *Septoria acicola,* was identified on several specimens received from various localities in eastern Kansas. The host in all cases was the Austrian pine (*Pinus nigra*). The prominent dark brown band bearing the black pycnidia was characteristic.

Although phloem necrosis of elms is not a fungus disease, it was considered advisable last year to make a few comments regarding its distribution in the state. The interest in this disease has increased during the year and additional trees have died in heavily infested areas in Kansas City, Lawrence, and Topeka. The disease now seems well established in east central Kansas but its spread westward probably will be slow due to fewer trees and greater proportion of open prairies. At present the western limit appears to be Manhattan where three trees were discovered during May and June. In one case the tree apparently had been infected the previous year, since the foliage showed unmistakable evidence of a serious condition when the leaves unfolded. They were small and yellowish green, giving the tree a thin, sickly appearance. Most of the roots were dead and the bark and wood were dead at the base of the trunk except for a small living area. This area revealed the characteristic wintergreen odor when the bark was placed in a closed jar for a few minutes. The other two trees leafed out apparently normally but wilted suddenly in June with the onset of warmer weather.

The Pocket Gopher, *Geomys quinni* McGrew, in the Rexroad Fauna, Blancan Age,[1] of Southwestern Kansas[2]

DOROTHEA S. FRANZEN
University of Kansas, Lawrence.

ABSTRACT: The outline and pattern of the fourth premolar is the chief diagnostic criterion employed in identifying maxillaries and mandibles of a pocket gopher, recovered from the Rexroad Formation, locality number three (Hibbard, 1941, p. 265) as belinging to *Geomys quinni* McGrew. A list of the associated vertebrate fauna is included.

Geomys quinni McGrew, 1944, pp. 49-59, fig. 16.

Occurrence of *Geomys quinni* in Kansas: Rexroad Formation, Meade County, Kansas, locality number 3 (Hibbard, 1941, p. 265). The following fragmentary skeletal elements were available for study:

No. 4539, a fragmentary right mandible with rp4 in place.[3]

No. 4771, a fragmentary right mandible with rp4 in place.

No. 4540, a fragmentary left mandible with lp4 in place.

No. 4770, a fragmentary left mandible with lp4 in place.

No. 4593, a fragmentary left mandible and associated fragmentary maxilliaries; one maxillary containing LP4.

No. 4733, a rostrum possessing the upper incisors.

Numerous isolated teeth, including some upper fourth premolars.

The above series of *Geomys quinni* from the Rexroad Formation was collected by field parties directed by Doctor Claude W. Hibbard, at that time Curator of Vertebrate Paleontology, University of Kansas Museum of Natural History.

In the series of the pocket gopher, *Geomys quinni,* from the Rexroad Formation, the element most frequently present was the fourth premolar. It was found that this tooth has certain reliable diagnostic characteristics such as the enamel pattern and the size of the reëntrant "angles".

A character of the upper fourth premolar of the gopher from the Rexroad sediments excludes this gopher from the genus *Nerterogeomys* Gazin (1942, p. 507). The upper fourth premolar of *Ner-*

[1]Elias, Maxim K., *et al,* 1945, pp. 270-271.

[2]Assistance is acknowledged from Doctor Claude W. Hibbard, formerly Curator of Vertebrate Paleontology, University of Kansas Museum of Natural History.

[3]p4 designates lower fourth premolar; P4 designates upper fourth premolar.

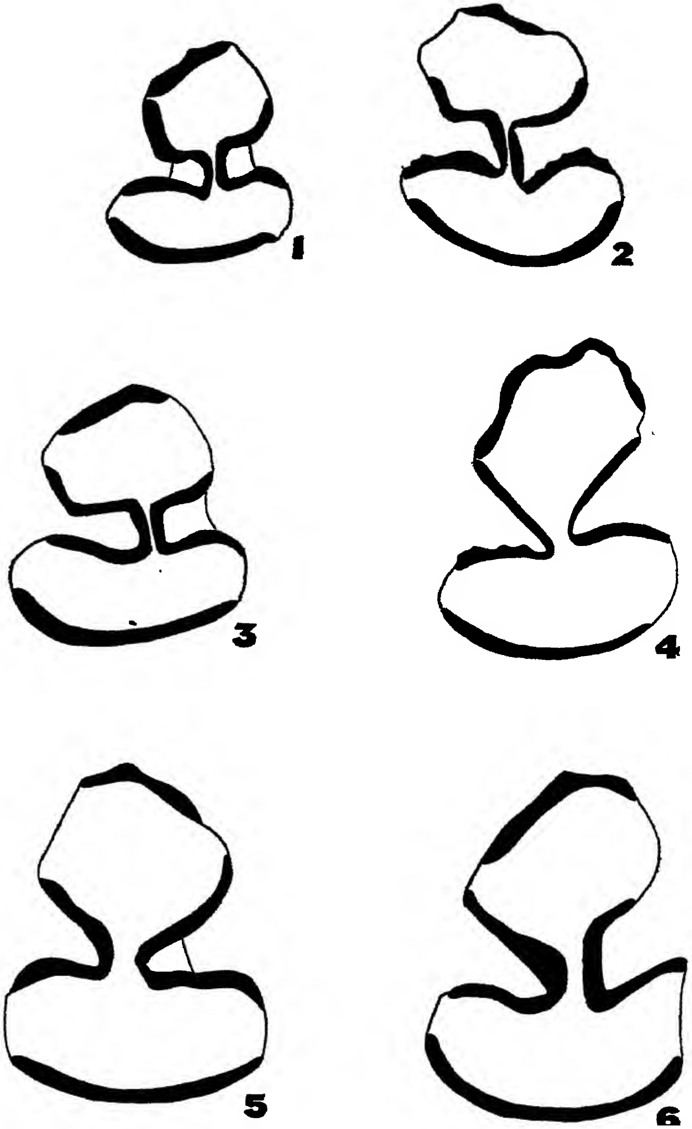


PLATE A.—Comparisons of the Lower Fourth Premolar.

Fig. 1.—K.U. No. 12988, rp4, of an immature individual, G. bursarius (Shaw), Recent.
Fig. 2—K.U. No. 5234, lp4, of a mature individual, Geomys sp., Pleistocene.
Fig. 3.—K.U. No. 14083, rp4 of a mature individual, G. lutescens, Recent.
Fig. 4.—K.U. No. 4771, rp4 of an immature individual, G. quinni, Rexroad.
Fig. 5.—C.M. No. F.M. P27011, lp4 of holotype, G. quinni, Sand Draw.
Fig. 6.—K.U. No. 4539, rp4 of a mature individual, G quinni, Rexroad.

All figures x12.

terogeomys is characterized by the presence of enamel across the posterior wall of the tooth, while enamel in this position is lacking in this tooth among the gophers from the Rexroad deposits.

The series of gophers from the Rexroad Formation was compared with the holotype and paratypes of *Geomys quinni* McGrew, Sand Draw deposit, (Blancan) Nebraska (McGrew, 1944, p. 49), available through the courtesy of Doctor Paul McGrew, Department of Vertebrate Paleontology, Chicago Natural History Museum, and also with a series of fossil *Geomys* sp. from Pleistocene deposits of Meade County, Kansas, and with two Recent species, *Geomys lutescens* (Merriam), Meade County, Kansas; and *Geomys bursarius* (Shaw), Douglas, Leavenworth, and Greenwood counties, Kansas. The last three series are in the University of Kansas Museum of Natural History, to which all catalogue numbers refer, unless otherwise indicated.

Several dental characters separate *Geomys quinni* from the Recent and the Pleistocene species of *Geomys* studied. The reëntrant "angles" of the upper and the lower fourth premolars of *Geomys quinni* are acute, both in the holotype and paratype series and in the series from the Rexroad Formation, whereas in the Recent and Pleistocene species studied they are rectangular in outline. Also, the reëntrant "angles" of *G. quinni* are wider and consequently the distance between the anterior and posterior lobes of the fourth premolars is greater than it is in the living and in the Pleistocene forms studied. Although the width of the reëntrant "angles" decreases with increased wear of the teeth, the width is consistently greater in individuals of *G. quinni* than it is in equally worn teeth of the Pleistocene and the Recent species. One may compare the reëntrant angles of p4 in *G. quinni* with those of the Pleistocene and Recent species by referring to Plate A.

In addition to the above mentioned maxillaries, a few disassociated P4 of pocket gophers from the Rexroad deposits were available for study. Because the reëntrant "angles" of these teeth corresponded in size and pattern to those of the holotype, they were identified as belonging to *G. quinni.*

The width of the reëntrant "angles" of p4 and P4 of the holotype and the paratypes were well illustrated by McGrew (1944, p. 50, fig. 16). However, a description of this feature was omitted.

Measurements of the occlussal length and width of p4 in several lots of specimens indicate only slight variations, as may be seen by inspection of the following table:

TABLE I.

	Occlusal Length of p4	Occlusal Width of Anterior Lobe of p4	Occlusal Width of Posterior Lobe of p4
Geomys quinni McGrew			
Holotype No. P27011, Field Museum	3.5 mm.	1.9 mm.	2.4 mm.
Paratype No. P26175, Field Museum	3.6	1.7	2.4
Paratype No. P14978, Field Museum	3.4	1.9	2.4
Kansas University, No. 4771	3.3	1.7	2.3
Kansas University, No. 4539	3.5	1.8	2.4
Kansas University, No. 4770	3.4	1.95	2.5
Geomys bursarius			
Kansas University, No. 3830 (immature)	2.7	1.25	1.9
Kansas University, No. 1102	3.2	1.9	2.4
Geomys lutescens			
Kansas University, No. 14083	2.6	1.7	2.3
Kansas University, No. 14084	2.9	1.5	2.2

Although the main emphasis in this study has been placed upon the characteristics of the upper and lower fourth premolars, certain other skeletal features were also studied. Only three of the specimens from the Rexroad Formation, locality number 3, Meade County, Kansas, included enough of the mandible to reveal the location of the mental foramen in relation to the masseteric ridge; the distance between the mental foramen and the masseteric ridge is comparable to that in the holotype and paratypes of *Geomys quinni*. In the Pleistocene and Recent individuals of *Geomys* studied, the distance from the mental foramen to the masseteric ridge and the distance from the mental foramen to anterior border of the alveolus of p4 is greater than in *G. quinni*. Comparisons of the zygomatic breadth, as made by McGrew (1944, pp. 49-50), in determining the species *Geomys quinni* could not be made because of the incompleteness of the specimens from the Rexroad fauna.

A second lot of gophers consisting of two fragmentary mandibles with complete dentition was also taken from the Rexroad Formation, locality number 3. In these individuals the mandibles and teeth are smaller than in *Q. quinni*, the width of the reëntrant "angles" of p4 is less, and the "angles" are rectangular instead of acute; furthermore, the spaces between the anterior and the posterior lobes are greater than in *G. quinni* or the Recent *Geomys* studied. Although these specimens are of small size, the enamel pattern is worn in a manner characteristic of mature gophers, which they probably are. These are thought to be of a species other than *G. quinni* and are here listed only as *Geomys* sp.

Vertebrates associated with *G. quinni* in the Rexroad Formation, locality number 3, have been studied by several authorities. The following is a list of those vertebrates reported by Hibbard (1941, pp. 265-313), Taylor (1941, pp. 16-176, and 1942, pp. 199-235), and Wetmore (1944, pp. 89-105):

Amphibians: *Scaphiopus diversus* Taylor, *Neoscaphiopus noblei* Taylor, *Bufo* sp., *Anchylorana moorei* Taylor, *Anchylorana dubita* Taylor, *Anchylorana robustocondyla* Taylor, *Rana fayeae* Taylor, *Rana meadensis* Taylor, *Rana ephippium* Taylor, *Rana rexroadensis* Taylor, *Rana valida* Taylor, *Rana parvissima* Taylor. Reptiles: *Eumecoides hibbardi* Taylor, *Eumecoides mylocoelus* Taylor. Aves: *Colymbus* sp., *Threskiornithid* sp., *Nettion bunkeri* Wetmore, *Charitonetta albeola* (Linnaeus,), *Colinus hibbardi* Wetmore, *Meleagris gallopavo* Linnaeus, *Rallus prenticei* Wetmore, *Fulica americana* Gmelin, *Sterna* sp., *Zenaidura macroura* (Linnaeus). Mammals: *Sorex taylori* Hibbard, Chiroptera, *Canis lepophagus* Johnston, *Procyon rexroadensis* Hibbard, *Brachyprotoma brevirramus* Hibbard, *Spilogale rexroadi* Hibbard, *Taxidea taxus* (Schreber), *Trigonictis kansasensis* Hibbard,*Citellus howelli* Hibbard, *Citellus rexroadensis* Hibbard, *Liomys centralis* Hibbard, *Perognathus gidleyi* Hibbard, *Procastoroides sweeti* Barbour and Schultz, *Peromyscus kansasensis* Hibbard, *Bensonomys arizonae* (Gidley), *Symmetrodontomys simplicidens* Hibbard, *Sigmodon intermedius* Hibbard, *Parahodomys quadriplicatus* Hibbard, *Ogmodontomys poaphagus* Hibbard, *Pratilepus kansasensis* Hibbard, *Notolagus lepuscula* (Hibbard), *Nekrolagus progressus* (Hibbard), *Hypolagus regalis* Hibbard, *Stegomastodon* sp., *Equus* (*Hippotigris*) *simplicidens* Cope, *Platygonus* sp., ?*Capromeryx* sp.

Literature Cited

Elias, Maxim K., *et al.*, 1945. Blancan as a Time Term in the Central Great Plains. Science, March 16, Vol. 101, No. 2620, pp. 270-271.

Gazin, C. Lewis, 1942. The Late Cenozoic Vertebrate Faunas from the San Pedro Valley, Arizona. Proc. of the U. S. Natl. Mus., Vol. 92, No. 3155, pp. 475-518.

Gidley, James W., 1922. Preliminary Report of Fossil Vertebrates of the San Pedro Valley, Arizona with Descriptions of New Species of Rodentia and Lagomorpha. Dept. of Int., U.S.G.S., Professional Paper 131—E., pp. 119-128, Pl. XXXIV-XXXV.

Hibbard, Claude W., 1941. Mammals of the Rexroad Fauna from the Upper Pliocene of Southwestern Kansas. Trans. Kans. Acad. Sci., Vol. 44, pp. 265-313, 4 pls.

McGrew, Paul O., 1944. An Early Pleistocene (Blancan) Fauna from Nebraska. Geo. Series, Field Museum of Natural History, Vol. 9, No. 2, Pub. 546.

Taylor, Edward H., 1941. Extinct Lizards from Upper Pliocene Deposits of Kansas. State Geol. Surv. Kans., Bull. 38, pt. 5, pp. 16-176, figs. 1-6.

———, 1942. Extinct Toads and Frogs from the Upper Pliocene Deposits of Meade County, Kansas. Univ. Kans. Sci. Bull., Vol. 28, pt. 2, no. 10, pp. 199-235, pls. 14-20.

Wetmore, Alexander, 1944. Remains of Birds from the Rexroad Fauna of the Upper Pliocene of Kansas. Univ. Kans. Sci. Bull., Vol. 30, pt. 1, no. 9, pp. 89-105, 19 figs.

Additions to the Flora of the Late Pleistocene Deposits at Ashmore, Illinois

EDWIN C. GALBREATH
Museum of Natural History, University of Kansas, Lawrence

In 1938 the writer reported upon the vertebrate fauna of some Pleistocene Gravels in East-Central Illinois. At that time, several fragments of wood representing *Larix, Hicoria,* and *Ulmus,* found associated with the faunal remains, were listed. Since publication of the list, several more discoveries of wood, seeds, and plant fragments have made possible the addition of eight new forms to the known flora of these beds.

Again the writer wishes to express his appreciation for the advice and assistance given by Dr. E. L. Stover of Eastern Illinois State College in the study of this flora.

The Ashmore Pleistocene Beds are composed of a series of gravels, clay, and black earth making-up the valley floor of Polecat Creek near Ashmore, Illinois, and having their inception during the retreat of the Shelbyville lobe of the Tazewell glacier.

Uppermost in these beds is a stratum of black earth which has continued into historic times. Underlying the black earth is a bed of brown alluvial gravel and sand interspersed with many lenses of muck. It is in this stratum of gravel, and especially the muck lenses, that the collection of wood, seeds, and plant fragments have been made. Below this brown gravel is a thin layer of blue clay which contains many unidentified branches and pieces of wood. At the same level as the blue clay, in a limited area of the beds, is a deposit of gravel, characterized by numerous larch cones. This larch cone gravel represents, possibly, a portion of an alluvial fan or dissected terrace, and may be but slightly older than the overlying beds. The basal deposit of this series consists of a gray gravel, an outwash of the Shelbyville lobe prior to deposition of its terminal moraine in that area, which has yet to yield any wood that can be recognized as coming from this bed.

List of Material Collected

Black Earth

Class Angiospermae.
Quercus sp. (Tourn.) L. Oak.

Brown or Alluvial Gravel

Class Ascomyceteae.
Pyronema sp. Carus. Sac Fungus.

Class Basidiomyceteae.
Fomes sp. Fr. Shelf Fungus.
Class Gymnospermae.
Larix sp. (Tourn.) Adams. Larch.
Picea sp. Link. Spruce.
Class Angiospermae.
Juglans cinera L. Butternut.
Juglans nigra L. Black Walnut.
Hicoria sp. Raf. Hickory.
Corylus (?) *americana* Walt. Hazelnut.
Ulmus sp. (Tourn.) L. Elm.

Blue Clay and Larch Cone Gravel

Class Gymnospermae.
Larix sp.

Gray or Basal Gravel

No definite record of wood.

The fauna associated with the flora collected from the alluvial gravel includes the Short-tailed Shrew, Cottontail Rabbit, Giant Beaver, Ground Sloth, Coyote, Indian Dog, American Mastodon, White-tailed Deer, Raccoon, Muskrat, an undetermined Ovibovid, and the Little Brown Crane. The following forms were removed from the deposit by a steam shovel and probably came from the alluvial gravel, but they were not actually seen in situ: Indian, Wolf, Grizzly Bear, Wapiti, Roosevelt's Deer-moose, Bison, Horse, Wild Turkey, Box Turtle, and two unidentified Emydid turtles.

This floral list contains representatives of the forms found in the area at the present time, with exception of larch and spruce, which may be stragglers from an earlier cooler climate. The absence of oak and maple from the alluvial gravels is interesting, and, when coupled with the abundance of larch and spruce, might be an indication that these beds were deposited in the later part of the Wisconsin as the deciduous forests were succeeding the conifer forests.

Bibliography

Fuller, George D. 1939. "Interglacial and Postglacial Vegetation of Illinois." Trans. Illinois State Acad. Sci., Vol. 32, no. 1, pp. 5-15.

Galbreath, Edwin C. 1938. "Post-glacial Fossil Vertebrates From East-Central Illinois." Geol. Ser., Field Mus. Nat. Hist., Vol. 6, no. 20, pp. 303-313.

———. 1939. "A Second Record of *Cervalces* From East-Central Illinois." Jour. Mammalogy, Vol. 20, no. 4, pp. 507-508.

———. 1944. "*Grus canadensis* From the Pleistocene of Illinois." The Condor, Vol. 46, no. 1, p. 35.

———. 1946. "*Equus* From the Pleistocene of Illinois." Jour. Mammalogy, Vol. 27, no. 1, pp. 81-92.

Migration Records of Birds in East-Central Kansas

R. F. MILLER and IVAN L. BOYD
Baker University, Baldwin, Kansas

The observations recorded in this paper were obtained during the years 1936 to 1947. In this paper the term "East-Central Kansas" means a strip of territory extending from Lake Quivira in Johnson County west to Lake Kahola in Morris County and from Lawrence and Topeka southward to Emporia, Williamsburg, and Richmond.

Besides the records compiled by the authors, additional records have been contributed by the following observers: R. E. Bugbee, formerly of Emporia; L. B. Carson, Topeka; Harold Hedges, Lake Quivira; Dr. H. M. Harford, Kansas City, Missouri; R. L. Montell, Lawrence; John Bishop, Kansas City, Kansas; Rev. Gordon Coldsmith, Richmond, and several members of the Baldwin Bird Club, particularly Mrs. Ivan L. Boyd, Miss Katharine Kelley, and Miss Amelia Betts.

The purpose of this paper is three-fold: (1) to give the amateur an opportunity to know what birds to expect to find in this particular area, (2) to indicate the habitat where each of these species may be found, and (3) at what time of the year to expect to find the species present.

The observations are grouped by quarter-months or approximately by weeks, with the following arbitrary date limits: 1-7, 8-15, 16-23, 24 to the end of the month, respectively. An "X" in any square means that an observation of the given species was taken during the indicated week at least once in the eleven-year period in which the records were made. In cases where the "X" symbols are scattered, the absence of a symbol for a given week does not necessarily mean that the bird was not present in the area under observation, but may show our failure to find it because of adverse conditions at the time.

Most of our records were obtained from field observations and no attempt was made to collect species. However, in a few cases specimens killed by collectors, hunters, or by motor cars have been listed. Species which were considered by the observers to be extremely rare, accidental, or difficult to identify were omitted from the list. Blank lines have been left at the foot of each page of the

Transactions Kansas Academy of Science, Vol. 50, No. 1, 1947.

chart so that those who care to do so may add their own observations of species not listed. We have listed only such subspecies as can be readily distinguished in the field.

No doubt our chart contains some mistakes in identification. We have, however, made serious efforts to avoid errors. In addition to using many books which describe and illustrate the various species of birds, we have made many comparisons with mounted specimens in museums, particularly at the Dyche Museum, University of Kansas, and at the Historical Building in Topeka.

The scientific names have been omitted as more confusing than helpful to beginners. The common names of the birds are used as they appear in Roger T. Peterson's "A Field Guide to the Birds," Houghton Mifflin Company, 1939. The names follow the sequence given in the fourth edition of the A. O. U. Check-list of North American Birds.

OCCURRENCE OF BIRDS IN EAST-CENTRAL KANSAS

Column A indicates relative abundance of the species, as follows:
a-abundant; *c*-common; *i*-infrequent; *r*-rare.

Column H indicates habitat, as follows: *b*-bridges, cliffs, etc.; *f*-farmland; *h*-near human habitation; *m*-marsh; *o*-open country; *s*-streams; *sh*-shore; *t*-scattered trees; *th*-thickets; *w*-water; *wd*-woods.

BIRDS	A	H	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Loon, Common	i	w			X X	XXXX		XXXX		X X		XX	XXXX	XX
Grebe, Horned	r	w			X X	X	X				X X	XX X	XX	
Grebe, Eared	r	w				XX	XXX							
Grebe, Western	r	w					X X					XX	X X	
Grebe, Pied-billed	c	w			XX	XXXX	XX		XXX	XXXX	XXX	XXXX		
Pelican, White	i	w	·				XX	X			X	XXX	X X	
Cormorant, Double-crested	i	w		X		XXX	X .				XXX	XXXX	XXX	X
Heron, Great Blue	c	sh			X	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XX	XXX	X X
Egret, American	i	sh				X			XX	XXXX	X			
Egret, Snowy	r	sh								X		X		
Heron, Little Blue	r	sh					X		X	X X	X X			
Heron, E. Green	c	sh			X	XX	XXXX	XXXX	XXXX	XXXX	XX			
Heron, Black-crowned Night	i	sh				XX X	XX			X	X X			
Heron, Yellow-crowned Night	r	sh							X	X				
Bittern, American	i	sh				X	XXX			X X	X X	X		
Bittern, E. Least	i	sh				X	X X	XX				X		
Goose, Canada	c	w			XXX	XXX						XX		X
Goose, White-fronted	i	w			XX	X								
Goose, Lesser Snow	c	w		X	XXX	X						XX	X	
Goose, Blue	c	w			XXX	X						X	X	
Mallard, Common	c	w	XXX	XXXX	XXX	XX	XXX	X			XX	XX	XXXX	XXX
Duck, Red-legged Black	i	w	XXXX	XX X	XXXX		X				X	X XX	XXXX	XXXX
Gadwall	c	w			XXX	XXXX	XX	X					XX	X
Baldpate	c	w	X		XXX	XXXX	X	X	X		X X	X XX	XXXX	X X
Pintail, American	c	w	XXXX	XXX	XXXX	XXXX	X XX	X		X		X XX	XXXX	XX
Teal, Green-winged	c	w		X	XX	XXXX					X X		X	

BIRDS	A	H	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Teal, Blue-winged	c	w			XX	XXXX	XXXX	XXXX		XX	XXXX	X X	X	
Shoveller	c	w			XXX	XXXX	XXX			X	X X	X	XXX	
Duck, Wood	r	w				X				X	XX	XXX	XX X	
Redhead	c	w	X		XXX	XX						XX	XX X	X X
Duck, Ring-necked	c	w	X		XXX	XXX		X				XX	XX	X
Canvas-back	c	w	X		XXXX	XXX							XXX	XX
Scaup, Lesser	c	w		X	XXX	XXXX	XXXX	XXX				XX	XX X	XX
Golden-eye, American	i	w			XXX	X	X						X	X
Buffle-head	i	w			XXX	XXX							XXX	
Old-squaw	r	w		XX									XXX	XX
Duck, Ruddy	c	w			X	XXX	XX					X	XX	
Merganser. Hooded	i	w	XXXX	XXXX	XXX	XX	X	X	X			X	XXXX	XXXX
Merganser, American	c	w	XXX	XXXX	XXX	XX	X		X			X	XX	XXX
Berganser, Red-breasted	i	w			XX	X X	X XX	X					X	X
Vulture, Turkey	c	o			X XX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	X		
Hawk, Sharp-shinned	c	wd	X	X	X	X	X				XX	X	X X	XX
Hawk, Cooper's	c	wd	X X		XX	XX	XX		XX	XX	X XX			X XX
Hawk, E. Red-tailed	c	o,t	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Hawk, Krider's	i	o,t	XXX	X		X						XX	X	
Hawk, W. Red-tailed	i	o,t	X	X										XX
Hawk, Harlan's	i	o,t	X XX	XXXX	XX	XX							X	X
Hawk, N. Red-shouldered	r	wd				X	X		X	X		X		X
Hawk, Broad-winged	i	wd				XX	X				X			
Hawk, Swainson's	c	o			XX	XXX	XXXX	X X	XXX	XXXX	X			
Hawk, American Rough-legged	i	wd	XX	·X	X	X					X	XXX	XXXX	
Eagle, Golden	r	o		XX		X							X	
Eagle, Bald	i	o	X	X	X									XXXX
Hawk, Marsh	c	o	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Osprey	c	w				XXX	XXX			X	XXX	XX	X	
Hawk, Duck	r	b,wd			X	X					X			
Hawk, Pigeon	r	o,wd		X	X									
Hawk, Sparrow	c	h,t	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

BIRDS	A	H	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Chicken, Greater Prairie	r	o				X							X	
Bob-white, E.	c	f	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Pheasant, Ring-necked	r	o				X								
Rail, King	c	m				X			X	XX				
Sora	i	m					XXX							
Gallinule, Florida	i	m					X							
Coot, American	c	m	X	X	XXX	XXXX	XXXX	XXXX	XX	X X	XXX	X XX	XXXX	XX
Plover, Semipalmated	c	sh			X	XXXX	XXX	XX	X	XXX	XX			
Killdeer	c	sh		X X	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XX	
Plover, American Golden	r	sh					X				X	X		
Woodcock, American	r	wd										X	X	
Snipe, Wilson's	c	sh		X	X	X XX	X						XX	
Plover, Upland	c	o				XXX	XXXX	XXXX	XXXX	XX X				
Sandpiper, Spotted	c	sh				XX	XXXX	XX	X X	XXX	XX	XX		
Sandpiper, E. Solitary	c	sh				XX	XXX		X	XX	X			
Willet, W.	r	sh				X	X							
Yellow-legs, Greater	i	sh			X	XXX	X			XX				
Yellow-legs, Lesser	c	sh			XX	XXXX	XXX	X		XX	XX	X	X	
Sandpiper, Pectoral	c	sh			XX	XXX	X		X	XXX				
Sandpiper, White-rumped	i	sh					X	XX						
Sandpiper, Baird's	i	sh					X			X X				
Sandpiper, Least	c	sh				XX	XXX			X	X			
Sandpiper, Red-backed	i	sh					X			X				
Dowitcher	i	sh				XX	XX					X		
Sandpiper, Stilt	i	sh				X	XXX				X			
Sandpiper, Semipalmated	c	sh			X	X X	XXX	XX	X	XXX	XX			
Sandpiper, Western	i	sh				X	X		X	X	X			
Sandpiper, Buff-breasted	i	o,sh							X	X	X			
Godwit, Hudsonian	i	sh				X	XX							
Sanderling	r	sh					X	X			X	X		
Phalarope, Wilson's	i	sh,m				XX	XXX			X				
Gull, Herring	c	w		XX	XXX	XXXX	X					X	XX X	

BIRDS	A	H	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Gull, Ring-billed	i	w			X	X						X	XXX	
Gull, Franklin's	c	w				XXX	X	X				XX	XX	X
Tern, Forster's	i	w				XX	XX	X	X	X	X X		X	
Tern, Common	i	w			X		XX	X			X	X		
Tern, Least	i	w					XXX	XXXX		X X				
Tern, Black	c	w					XXXX	XXXX		XXX	XX			
Dove, E. Mourning	a	t,f	XXXX	X XX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXX	X	XX
Cuckoo, Yellow-billed	c	wd				X	XXXX	XXXX	XXXX	XXXX				
Cuckoo, Black-billed	r	wd					XXX	X	X	X	XXX	X		
Owl, Barn	r	f,h		X		X								
Owl, E. Screech	c	wd	X	X	X	X	X	X	XX	X XX	X X	X	X X	X X
Owl, Great Horned	c	wd	X XX			XX	X X	X	X X	XXXX	X X	X		X X
Owl, N. Barred	c	wd	XX X	XXXX	X XX	XX	X X	X X	XXX	XX	XXXX	X		XXXX
Owl, Long-eared	r	wd		X										
Owl, Short-eared	r	o												X
Chuck-will's-widow	c	wd					XXX	XXXX	XXXX	XXX				
Whip-poor-will	c	wd				XXX	XXXX	XXXX	XXXX	XXX	X X			
Poor-will, Nuttall's	i	o							X		X			
Nighthawk, E.	c	o				X	XXXX	XXXX	XXXX	XXXX	XXXX			
Swift, Chimney	a	h				XXX	XXXX	XXXX	XXXX	XXXX	XXXX	XX		
Humingbird, Ruby-throated	c	h,wd				X	XXXX	XXXX	XXXX	XXXX	XXXX	X		
Kingfisher, E. Belted	c	w	X	XX	X	XXX	XXXX	XXXX	XXXX	XXXX	XXXX	X XX	XXX	X
Flicker, N.	c	wd	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Flicker, Red-shafted	i	wd	XXX	XXXX	XXX							XXXX	XXX	XXXX
Woodpecker, Red-bellied	c	wd	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Woodpecker, Red-headed	c	wd	XXX	X X	X	X XX	XXXX	XXXX	XXXX	XXXX	XXXX	XX	X	X XX
Sapsucker, Yellow-bellied	i	wd	XXX	XXX	X	XXX							XX	XX X
Woodpecker, E. Hairy	c	wd	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Woodpecker, N. Downy	c	wd	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Kingbird, E.	c	o				XXX	XXXX	XXXX	XXXX	XXXX	XXX			
Kingbird, Arkansas	i	o					XXXX	XXX	X X	X	XX			
Flycatcher, Scissor-tailed	c	o				XX	XXXX	XXXX	XXXX	XXXX				

BIRDS	A	H	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Flycatcher, N. Crested	c	t				X	XXXX	XXXX	XXXX	XXXX	X			
Phoebe, E.	c	b			XX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXX		
Flycatcher, Acadian	i	wd				X	X XX	X X	X X		X			
Flycatcher, Alder	i	wd					X X			X	X			
Flycatcher, Least	c	wd				X	XXXX							
Pewee, E. Wood	c	wd					XXXX	XXXX	XXXX	XXX				
Flycatcher, Olive-sided	i	wd					X				XXX			
Lark, Prairie Horned	c	o	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Swallow, Tree	c	t,w				XXXX	XX			X	X			
Swallow, Bank	c	b				XXX	XXXX	XX X	XX X	X XX	XX			
Swallow, Rough-winged	i	b			X	XXX	X	XXX	X					
Swallow, Barn	c	h				XXX	XXXX	XXXX	XXXX	XXXX	XXXX	X		
Swallow, N. Cliff	c	b				X	XXXX	XX		XXX				
Martin, Purple	c	h			XX	XXXX	XXXX	XXXX	XXXX	XXX				
Jay, N. Blue	c	t	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Crow, E.	a	f,wd	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Chickadee, Black-capped	c	t	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Titmouse, Tufted	c	wd	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Nuthatch, White-breasted	i	wd	XXX	XXXX	X	XX	XXX	X	XXX	X				X X
Nuthatch, Red-breasted	i	wd	XXXX	XXXX	XXXX	X							X	XXX
Creeper, Brown	c	wd	XXXX	XXXX	XXXX	XXX						X XX	XXXX	XXXX
Wren, W. House	c	h				XXXX	XXXX	XXXX	XXXX	XXXX	XXX	X		
Wren, E. Winter	i	s,wd	X X	XXX	XXX							X X	X XX	XXXX
Wren, Bewick's	c	h			XXX	XXXX	XXXX	XXXX	XXXX	XXXX	X	XX		
Wren, Carolina	i	wd	X		X X	XXXX	X X	X	X	X		X	X X	XX X
Wren, Prairie Marsh	i	m				X	X				XX X	X X		
Wren, Short-billed Marsh	i	m					X			X X		X X		
Mockingbird, E.	c	t	XXXX	XXXX	XX	XXXX	XXXX	XXXX	XXXX	XXXX	X	X	X	XXXX
Catbird	c	th				X	XXXX	XXXX	XXXX	XXXX	XXXX			
Thrasher, Brown	c	th			X	XXXX	XXXX	XXXX	XXXX	XXXX	X X			
Robin, E.	a	h,t	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Thrush, Wood	i	wd				X	XXXX	XXXX	XXX					

BIRDS	A	H	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Thrush, E. Hermit	r	wd				XX	X							
Thrush, Olive-backed	c	wd				X	XXXX	X						
Thrush, Gray-cheeked	c	wd				X	XXX							
Veery	i	wd					X X							
Bluebird, E.	c	t	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Gnatcatcher, Blue-gray	c	wd				XXXX	XXXX	XXXX	XXXX	X X				
Kinglet, E. Golden-crowned	c	wd	XXX	X	XX	XX						X	XXXX	XXXX
Kinglet, E. Ruby-crowned	c	wd	X		X	XXXX	XX					XXXX	X	XX
Pipit, American	i	o			X X	XX						XX		X
Waxwing, Cedar	c	t	X X	XXX	XXXX	X	XXXX	XXX			XX	X	XX	X XX
Shrike, N.	i	o	XX	X										
Shrike, Migrant	c	o	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Starling	a	h,t	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Vireo, White-eyed	i	wd					X	XX						
Vireo, Bell's	c	th				XXX	XXXX	XXXX	XX	X XX	X			
Vireo, Yellow-throated	c	wd				X	XXXX	X XX	X X		XX			
Vireo, Blue-headed	i	wd				X	XX							
Vireo, Red-eyed	c	wd				X	XXXX	XXXX	XXXX	X				
Vireo, Warbling	c	t				XX	XXXX	XXXX	XXX	X XX	X			
Warbler, Black and White	c	wd				XX	XXXX				X			
Warbler, Prothonotary	i	s,wd				X	XXX	X	X					
Warbler, Golden-winged	r	wd					X							
Warbler, Blue-winged	i	wd					XXX							
Warbler, Tennessee	c	wd				XX	XXXX							
Warbler, Orange-crowned	c	wd				XXX	XXX							
Warbler, Nashville	i	wd				X	XXX							
Warbler, Parula	c	wd				XX	XXXX	XXXX	XX					
Warbler, Yellow	c	t				XX	XXXX	XXX						
Warbler, Magnolia	i	wd					XXX				X			
Warbler, Myrtle	c	wd				XXX	XX					XXXX	X	
Warbler, Black-throated Green	i	wd					XX							
Warbler, Cerulean	i	wd					XX							

BIRDS	A	H	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Warbler, Blackburnian	i	wd				X	XXXX				X			
Warbler, Chestnut-sided	i	wd					XXX				X			
Warbler, Bay-breasted	r	wd					X							
Warbler, Black-poll	c	wd				X	XXX							
Warbler, N. Prairie	i	wd				X	XX X	XX	XXX	X X				
Warbler, Palm	i	wd				X	X							
Ovenbird	c	wd				X	XXX	X		X	X X			
Waterthrush, Grinnell's	i	wd,s				XX	X XX				X			
Waterthrush, Louisiana	c	wd,s					XXX		X					
Warbler, Kentucky	c	wd,s					XXXX	XXXX	XXX					
Warbler, Connecticut	r	wd					X							
Warbler, Mourning	i	wd					XX							
Yellowthroat, N.	c	th				XX	XXXX	XXXX	XXXX	X X				
Chat, Yellow-breasted	c	th					XXXX	XXX	XXXX	X				
Warbler, Wilson's	i	wd					XXX							
Warbler, Canada	i	wd					X				X			
Redstart, American	i	wd					XXXX	X						
Sparrow, English	a	h	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Bobolink	i	f,o					XXX							
Meadowlark, E.	a	o	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXX	X X	X XX
Meadowlark, W.	c	o	X X		XX	XXX	XXX	X	X X					
Blackbird, Yellow-headed	i	m				XXXX	XX	X	X		X			
Red-wing, E.	c	m		XXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	X	XXX	XX X	X
Oriole, Orchard	c	t				X	XXXX	XXXX	XXXX	XX X				
Oriole, Baltimore	c	t				X	XXXX	XXXX	XXXX	XXXX	XX			
Blackbird, Rusty	i	m,o			XXX	XX							X	X
Blackbird, Brewer's	i	o,f		X	XX	XXX					X	X	X	
Grackle, Bronzed	c	f,t	X	X	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	X XX	XXX	
Cowbird, E.	c	f,t		X	XXX	XXXX	XXXX	XXXX	XXXX	XXXX	X	X		
Tanager, Scarlet	c	wd					XXXX	XXXX	XXX					
Tanager, Summer	c	wd					XXXX	XXXX	XXXX		X			
Cardinal, E.	c	t	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

BIRDS	A	H	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Grosbeak, Rose-breasted	c	t				X	XXXX	XXXX	XXXX					
Grosbeak, E. Blue	i	th					X	XXXX	XXXX					
Bunting, Indigo	c	wd					XXXX	XXXX	XXXX	XXX				
Bunting, Painted	i	th					XXXX	XXXX	XXXX	X				
Dickcissel	c	o				XX	XXXX	XXXX	XXXX	XXXX	X			
Finch, E. Purple	i	t	XXX	XXX	XXX	XXXX						X	XX X	XXX
Siskin, N. Pine	i	t		X	XX	XXXX	X						X X	X
Goldfinch, E.	a	t	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Towhee, Red-eyed	c	wd	XX	X	XX	XXXX	XXXX	XXXX	XXX	X X				X X
Towhee, Arctic	i	wd	XXX	XXXX	XX							X	X	X XX
Sparrow, E. Savannah	c	m		X	XXX	XXXX	XX					X X	X	X
Sparrow, E. Grasshopper	c	f				XXX	XXXX	X	X XX	X				
Sparrow, Leconte's	i	f			XXX	XXXX						X		
Sparrow, Nelson's	r	f				X								
Sparrow, E. Vesper	i	f			XX	XXX							X	
Sparrow, E. Lark	c	f			X	XXXX	XXXX	XXXX	XXXX	XXXX				
Junco, Slate-colored	c	wd	XXXX	XXXX	XXXX	XXXX						XX	XXXX	XXXX
Sparrow, E. Tree	c	wd	XXXX	XXXX	XXXX	XXX						X	XXXX	XXXX
Sparrow, E. Chipping	c	t			X	XXXX	XXXX	XXXX	XXXX	XXXX		X		
Sparrow, Clay-colored	i	t				XX	XX							
Sparrow, E. Field	c	t	X	XX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX		XXX		X
Sparrow, Harris's	c	th	XXXX	XXXX	XXXX	XXXX	XXX					XX	XXXX	XXXX
Sparrow, White-crowned	i	th				XXX	XX X					X		X
Sparrow, White-throated	c	th		X	X	XXXX	XXX					XXXX	XX	
Sparrow, E. Fox	i	th,t		X X	XXXX	XX						X	XXX	X
Sparrow, Lincoln's	i	wd			X	XXXX	XXX					XX	X	
Sparrow, Swamp	i	m	X		XXX	XXXX	X				X	XXX	X X	
Sparrow, E. Song	c	s,th	XXXX	XXXX	XXXX	XXXX						XX	XXXX	XXXX
Longspur, Lapland	i	o	XXX	X XX	X								X	X XX

Kansas Botanical Notes, 1946, Including Species New to the State[1]

FRANK C. GATES
Kansas State College, Manhattan, Kansas.

At Manhattan, 1946 was an extraordinarily early season, so much so that by April 10 the season was at least four and a half weeks ahead of normal. Plants blossomed early and the blossoming period was short, more so than in any other year of which we have had experience. Since, in the 20-odd years of records, there never have been so many plants establishing a new earliest record, it may be worth while to list such with their new date of first blooming:

Flowering Date in 1946, the Earliest on Record at Manhattan

Acer ginnala, April 4.
Aesculus hippocastanum, April 24.
Allium perdulce, March 23.
Androsace occidentalis, March 23.
Arisaema dracontium, April 27 (first April record).
Asimina triloba, March 28 (first March record).
Baptisia minor, April 25 (first April record).
Callirhoe involucrata, April 27 (first April record).
Carex heliophila, March 23 (first March record).
Catalpa speciosa, May 14.
Celtis occidentalis, March 30.
Cercis canadensis, March 30.
Chaenomeles lagenaria, March 15.
Convallaria majalis, April 13.
Crataegus sp., April 10.
Descurainia intermedia, April 6.
Dicentra eximia, April 3.
Ellisia nyctelea, April 16.
Exochorda grandiflora, March 31.
Glecoma hederacea, April 5.
Iris pumila, March 23.
Isopyrum biternatum, March 21.
Kerria japonica, April 4.
Liriodendron tulipifera, May 2.
Lithospermum linearifolium, April 5.
Lonicera tatarica, March 17.
Medicago lupulina, April 23.
Medicago sativa, May 1.
Melilotus officinalis, May 2.
Mirabilis nyctaginea, May 4.
Oxalis violacea, April 1.
Phlox divaricata, April 1.
Pinus banksiana, April 2.
Pisum sativum, April 27.
Poa pratensis, April 22.
Podophyllum peltatum, April 13.
Polygonatum commutatum, May 1.
Prunus angustifolia watsoni, March 28.
Prunus virginiana, April 21.
Pyrus communis, March 22.
Quercus maxima, April 7.
Quercus muhlenbergii, April 6.
Rhodotypus kerrioides, April 3.
Ribes missouriense, March 31.
Ribes odoratum, March 25.
Robinia hispida, May 1.
Robinia pseudoacacia, April 20.
Smilacina stellata, April 16.
Syringa persica, March 31.
Thuja orientalis, microsporangiate, February 25.
Thuja orientalis, megasporangiate, March 10.
Tradescantia bracteata, April 25.
Tradescantia tharpii, March 31.
Trifolium repens, March 31.
Verbena bipinnatifida, April 18.
Viburnum prunifolium, April 22.
Viola papilionacea, March 23.
Yucca glauca, May 2.
Zanthoxylum americanum, April 6.
Zygadenus nuttallii, April 21.

Nine others in addition tied their previous earliest record date.

After the unprecedented earliness of the season, cold weather

Transactions Kansas Academy of Science, Vol. 50, No. 1, 1947.

[1]Contribution No. 485, Department of Botany and Plant Pathology.

dominated in late April and much of May. This had the effect of preventing the full expansion of the leaves of some of the trees which flower in early May. This was particularly noticeable in the pin oak, *Quercus palustris,* and in the Ohio Buckeye, *Aesculus glabra.*

There were more instances of fall blossoming than usual. Most untimely was the blossoming of certain shrubs in December, 1946. This December was warm and moist, even though there were heavy frosts in November. The shrubs included *Chaenomeles lagenaria.* (in flower December 16), *Syringa persica, Syringa vulgaris, Weigela florida* and *Forsythia suspensa. Forsythia* commenced blossoming in late November and leaves appeared in mid-December, a fact previously unrecorded to my knowledge.

Fruiting was extraordinarily abundant in the redbud, *Cercis canadensis,* in the fall.

Fasciations were noticed in *Tragopogon porrifolius* in Stafford County by Miss Emma Maupin in May, and in *Sesemum indicum* on the Agronomy farm at Manhattan during the summer.

But little was done in the herbarium and comparatively few plants were received from Kansas. Among important accessions were plants from Saline County by John Hancin, Miami County from Bernard Rohrer, Jefferson County by Nellie Jacobs, and Labette County from M. F. Jones.

Species New to the State

Centaurea calcitrapa L., a weed new to the state was collected near Parsons, Labette County, on July 13, 1946, by M. F. Jones.

During the year Dr. W. H. Horr, at the University, published a short article entitled "Kansas Plants New to Kansas Herbaria," in The University of Kansas Science Bulletin, Vol. 31, Pt. 1: 183-184. 1946. In this article ten species are listed as new records for Kansas, of which the following were not on our previous Kansas list: *Botrychium dissectum* Spreng. from Miami County, 1942; *Eleocharis rostellata* Torr. from the Meade County State Park by Dr. C. W. Hibbard in 1942; *Leersia lenticularis* Michx. in Miami County in 1938; *Erythronium americanum* Ker. in Cherokee County in 1943; *Lamium purpureum* L. Douglas County in 1940, altho it had been growing there, the article states, for at least 25 years previous; *Physocarpa intermedia* (Rydb.) C. K. Schneider in Cherokee County in 1943; and *Senecio glabellus* Poir in Cherokee County in 1943.

Scirpus acutus Muhl., given as *Scirpus occidentalis* (S. Wats.) Chase in the paper, had been collected several years previous (1892) to that stated in the paper.

Chaetopappa asteroides DC., Wilson County in 1937, was earlier than the previous collection we had in Chautauqua County in 1941. What is given as *Bidens laevis* (L.) B.S.P. from Meade County in 1945 needs further investigation in the present uncertain specific condition of *Bidens*. *Bidens laevis* is considered as a more eastern and northern plant by recent authors.

In closing, I would like to say that we would welcome duplicate specimens of species additional to the flora of Kansas in the State Herbarium at Manhattan and also that specimens additional to any of the counties of the state will be placed in the State Herbarium.

Early Observations on the Elk in Kansas

DONALD F. HOFFMEISTER
University of Kansas, Museum of Natural History.

The elk, more properly called the wapiti, is now extinct in Kansas, although in the 1800's it was said to be common over most of the state. Unfortunately, there is little published information on the abundance or site of occurrence of the wapiti in Kansas. Knox in his catalogue of mammals of Kansas, published in 1875, makes the brief comment, "Quite common in the west part of the state" (Trans. Kansas Acad. Sci., 4:20, 1875). Even less information can be obtained from specimens that were saved, because of the paucity of the material. In the collections of the Museum of Natural History of the University of Kansas, there is no specimen, nor part of a specimen, of an elk, other than remains of fossil elk, which occurred naturally in Kansas. As specimens are recovered, be they mounted heads, only sets of antlers, or other parts of the skeleton, with information as to where they were collected, our knowledge of the distribution of the wapiti in Kansas will increase.

Of especial interest with regards to the early history of the wapiti are three letters written in 1892 by Mr. J. R. Mead, of Wichita, Kansas, to Professor L. L. Dyche. Mead was an enthusiastic observer of big game and in letters to Dyche accurately recorded much information, not only about elk, but also about bison, mountain lions, and badgers. Mead's observations on the elk in Kansas are worthy of record. "In 1859 to 64", Mead writes in his letter of March 12, 1892, "the Eastern range of Elk in Kansas would be a line drawn north and south through Eldorado [,] Butler Co[unty]. All country west of that in Kansas was ranged over by them and I presume occasionaly [*sic*] east of that line."

On March 13, 1892, Mead wrote, "Elk followed the timbered creeks, probably for the brouse they seemed to prefer. For instance, a herd would cross the Solomon [River] coming from the North. At or near the mouths of some stream follow that stream up to its head. Cross the divide to say the head of Spillman's Creek, follow it down to its mouth. Then follow the valley of Saline River down a few miles feeding as they went to the big ford at the narrows where Lincoln now stands [,] cross there, and feed along up Elkhorn Creek to the head of Alum Creek and follow that down to the Smoky Hill River, and from there went I do not know where. . . .

I only saw them [large herds of a "1000 more or less"] in summer or fall. But old Bulls were found in the broken hills between Saline and Solomon [rivers] all winter . . . [The elk] preferred broken country with timbered cañons and streams and were not plentiful in the level tree country adjacent to the Arkansas [River]. . . . Elk were much more numerous north of the Smoky Hill River in Kansas than south of it . . ."

In describing the abundance of the elk in the 1850's and 1860's, Mead writes on March 11, 1892, "I have seen 1000 more or less in one drove, and they crossed the Saline [River] at the ford right where the town of Lincoln now stands. . . . I have killed Elk on the Solomon, Saline, Smoky Hill, and Arkansas rivers and their tributaries. . . . Have seen 50 to 100 in a drove in the Indian Ter[ritory] just over the line 10 miles below Kiowa, Barber County [thus, near Burlington, Alfalfa County, Oklahoma]. Have known them killed in Butler Co. [Kansas,] on the Walnut [River]."

"In what is now Lincoln, Mitchell, Osborne, Smith, Phillips, and Rooks counties", writes Mead on March 13, 1892, ". . . I frequently saw where large herds had recently [stopped?] and occasionaly [*sic*] saw the animals themselves."

In western Kansas, elk were still fairly abundant in 1871, for J. A. Allen, in reporting upon the mammals observed chiefly in the vicinity of Fort Hays, wrote, "More or less common near the streams, especially on Paradise Creek, and occurs as far east at least as Fort Harker [Ellsworth County]" (Bull. Essex Institute, 6:48, 1874). It was in this same paper (*op. cit.*, p. 45) that Allen regarded, upon the basis of reports of local residents, the ring-tailed cat, *Bassariscus astutus*, as occurring in western Kansas. Based upon this reference, Knox (Trans. Kansas Acad. Sci., 4:19, 1875) included *"Bassaris astuta"* in his "Kansas Mammalia." The ring-tailed cat has been omitted from subsequent lists of Kansas mammals and I know of no specimens taken within the state.

Some New Species of Taphrina

A. J. MIX
University of Kansas, Lawrence.

In the course of a revision of the genus *Taphrina*, now nearly completed, a number of undescribed species have been encountered. These, together with their names and descriptions, are here presented:

1. *Taphrina blechni* Bresadola.

Mycelium sub cuticula crescit. Asci amphigeni sunt, clavati, apice truncati, frequenter cum pede curvato, 23-60μ longi $\times$ 4-7μ lati. Cellulae basilares desunt. Spori ellipsoidei sunt, 2-5μ $\times$ 2-4μ, vel elongati, 5-6.5μ $\times$ 0.5-1.5μ.

Maculas parvas, orbiculares vel ellipsoideas, non deformatas, in foliis *Blechni* sp. gignit.

Mycelium is subcuticular. Asci are amphigenous, clavate, truncate at the apex, often with a curved foot, 23-60μ long $\times$ 4-7μ broad, lacking a stalk cell. Spores are ellipsoidal, 2-5μ $\times$ 2-4μ, or elongate, 5-6.5μ $\times$ 0.5-1.5μ. (Fig. 1, F).

Causes small, round or ellipsoidal spots, not thickened, on leaves of *Blechnum* sp. Serra Geral, Rio de Janeiro, Brazil, Oct. 1891, E. Ule.

Type material in Mycological Herbarium, University of Kansas. Duplicate (E. Ule. Herb. Brasil. 1786) in Botanical Museum, Berlin (in 1939), and in Botanical Museum, Stockholm.

This fungus is mentioned by Laubert (in Sorauer, Handb. d. pflanzenkr. vol. 2, p. 457, 1928) apparently on the basis of the specimens in the Berlin Museum. A portion of this collection was given to the writer by Dr. E. Ulbrich, and on this the above description is based. The Berlin and Stockholm specimens are labelled "*Taphrina Blechni* Bresadola n. sp.". According to Dr. Ulbrich the Berlin specimens were not accompanied by a description of the fungus. Enclosed in the packet containing the Stockholm specimens is a description written on a piece of newspaper, presumably in Bresadola's handwriting. This is only partly decipherable as follows: "*Taphrina Blechni* n. sp. Maculis . . . rufidulomarginatis, amphigenis, nonbullatis, ascis 8 sporis, clavatis, 30-36 $\times$ 6-7, apice . . . vel truncatis, basi attenuatis, . . . sporidiis elongato-subglobosis, 4-6 $\times$ 1¼. Affinis *T. filicina* Rostr. sed maculae nonbullatis". No sig-

nature is appended. On the same piece of paper is a pencil sketch showing two asci, each with bent foot and elongate spores.

The host-species is not identifiable from the small fragment of leaf in each of these collections.

It is apparent that Bresadola intended to describe this fungus as a new species but no published description can be found. Dr. Ulbrich kindly wrote to Dr. Killermann in Regensburg, where a complete collection of Bresadola's writings was then housed, but he was unable to find any reference in them to *Taphrina blechni.* Since Bresadola's description is lacking one has been supplied above.

Material of this fungus available for study is meager and it has not been possible to decide as to the nature of the spores. It is thought, however, that the ellipsoidal spores are ascospores and that the narrow, elongate spores are either blastospores or cells formed by conjugation of ascospores.

2. *Taphrina populi-salicis* sp. nov.

Asci hypophylli sunt, oblongi et cylindrati, apice rotundati, 50-106μ longi $\times$ 13-30μ lati. Cellulae basilares aut breves et cuneatae aut longae et fastigatae, interdum bifurcae sunt, 7-92μ longae $\times$ 7-27μ latae, in matricem alte penetrantes. Spori numerosi sunt, elliptici, ovati, aut anguste-elongati, 1.5-5μ $\times$ 0.5-4.5μ. Globuli oleosi, aureo-flavi, in ascis frequenter occurrunt.

Maculas deformatas, aureo-flavas in pagina inferiore folii *Populi fremontii* S. Wats., *P. trichocarpae* Torr. et Gray, *Salicis laevigatae* Bebb. gignit.

Asci are hypophyllous, oblong and cylindrical, rounded at the apex, 50-106μ long $\times$ 13-30μ broad; stalk cells are either short and wedge-shaped or long and tapering, sometimes forked, 7-92μ long $\times$ 7-24μ broad, penetrating deeply into host tissues. Spores are numerous, elliptical, ovate or narrowly elongate, 1.5-5μ $\times$ 0.5-4.5μ. Often golden yellow oil globules occur in the asci. (Fig. 1, C).

Causes golden yellow deformed spots on the under side of the leaf of *Populus fremontii* S. Wats., *P. trichocarpa* Torr. et Gray, and *Salix laevigata* Bebb.

Type material in Mycological Herbarium, University of Kansas.

This fungus causes leafspots entirely like those produced on *Populus nigra* and on several other species of *Populus* by *Taphrina populina* Fr. (T. *aurea* auct.). It differs considerably from that fungus. The asci are much larger and are always provided with a stalk cell. (Stalk cells may be present or absent in *T. populina*).

These stalk cells may be short and either wedge-shaped or blunt, but for the most part are long, tapering and rhizoidal, occasionally

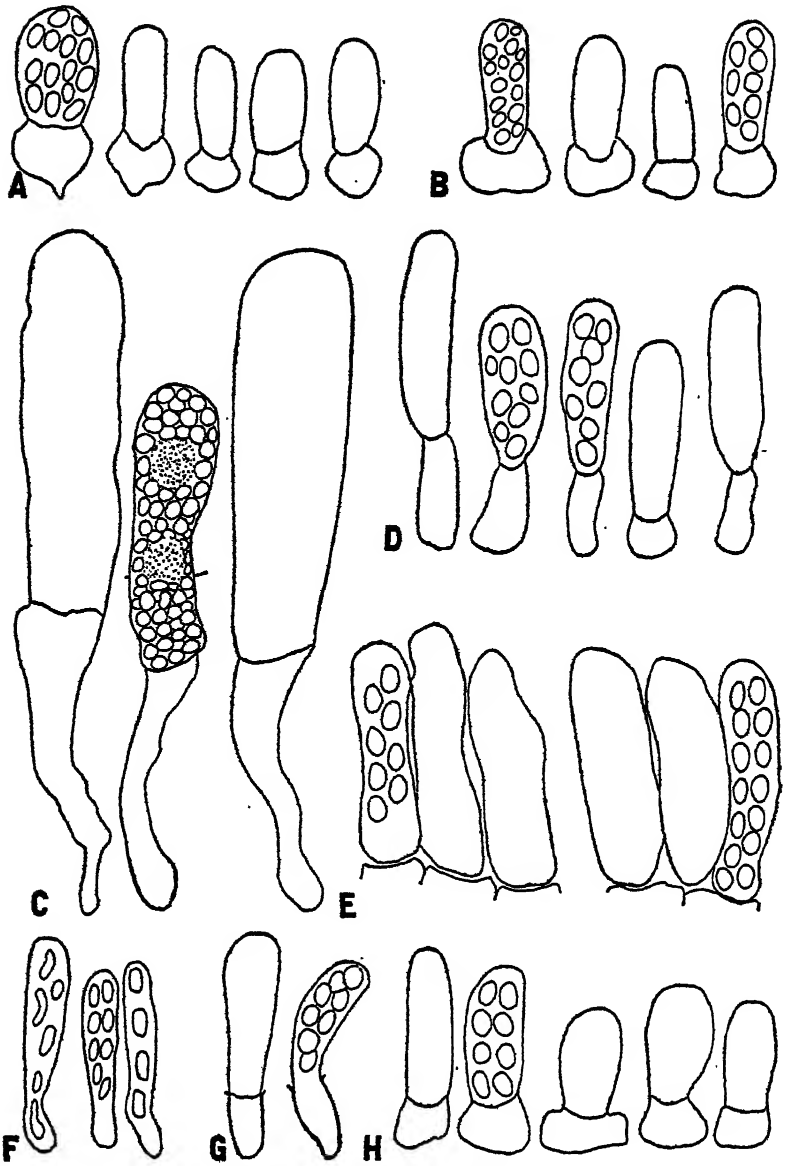


Figure 1.—Asci (×900) of: A, Taphrina americana from B. papyrifera; B, same from B. fontinalis; C, T. populi-salicis; D, T. padi; E, T. orientalis; F, T. blechni; G, T. thomasii; H, T. darkeri.

forked. The two fungi seem to be biologically, as well as morphologically, distinct.

Taphrina populi-salicis is known from several localities in California, Oregon and British Columbia. The collections designated as types are: *P. fremontii.* CALIFORNIA: Berkeley, July 10, 1938, H. N. Hansen. *P. trichocarpa.* OREGON: Lane Co., Eula, June 13, 1920, J. S. Boyce. *S. laevigata.* CALIFORNIA: Lassen Co., Mineral, Sept. 10, 1911, E. P. Meinecke.

3. *Taphrina americana* sp. nov.

Asci cylindrati sunt, apice rotundati aut truncati, 17-40μ $\times$ 8-18μ. Cellulae basilares latiores quam asci sunt, breves et rotundatae, truncatae aut basi acutae, 6-20μ $\times$ 7-23μ. Ascospori sunt orbiculares aut elliptici, 4-6μ $\times$ 3.5-5.5μ. "Scopas sagarum" in ramis *Betulae fontinalis* Sarg., *B. luteae* Michx., *B. papyriferae* Marsh. gignit.

Asci cylindric, rounded or truncate at the apex, 17-40μ $\times$ 8-18μ. Stalk cells broader than the asci, short, and rounded, truncate or pointed at the base, 6-20μ $\times$ 7-23μ. Ascospores round to elliptic, 4-6μ $\times$ 3.5-5.5μ. Causes witches' brooms on branches of *Betula fontinalis* Sarg., *B. lutea* Michx., *B. papyrifera* Marsh. El Vado, Boulder Canyon, Boulder, Colorado, July 27, 1942, A. J. Mix (*B. fontinalis*); Alpine Garden, Mt. Washington, New Hampshire, no date, R. Thaxter (*B. lutea*); ibid. July 1886, R. Thaxter (*B. papyrifera*). Type material in Mycological Herbarium, University of Kansas. (Fig. 1, A, B,).

Besides the above-named specimens the following were also studied: *B. papyrifera,* Solon Springs, Wisconsin, June 20, 1914, J. J. Davis; *B. fontinalis* (as *B. occidentalis* Hook.) Larimer County, Colorado, tributaries of South Fork, Cache Le Poudre River, Happy Hollow, July 2, 1896, L. H. Pammel (Mentioned by Hume, Davenport Acad. Sci. Proc. 7:246-257. 1899).

This fungus, resembling both *Taphrina betulina* Rostr., and *Taphrina nana* Johans., is intermediate in ascus-size between the two. In further contrast to these European species it is known only from North America, occurring on American species of *Betula.*

4. *Taphrina orientalis* sp. nov.

Asci hypophylli sunt, cylindrati, apice rotundati, in epidermide siti, non penetrantes, 22-46μ longi $\times$ 8-17μ lati. Cellula basilaris deest. Ascospori globosi aut elliptici sunt, 4-6μ $\times$4-5μ, in asco frequenter germinantes. Blastospori numerosi sunt, ascum complentes.

Maculas parvas (usque ad 8 mm. diam.) deformatas in foliis *Pyri lindleyi* Rehd. gignit.

Asci are hypophyllous, cylindric, rounded at the apex, seated on epidermis, not inserted, lacking a stalk cell, 22-46μ × 8-17μ; ascospores round or elliptic, 4-6μ × 4-5μ; often budding in the ascus. Blastospores numerous, filling the ascus. Causes small (up to 8 mm. diam.) deformed spots on leaves of *Pyrus lindleyi* Rehd. Morioka Pref. Iwate, Japan, May 20, 1908, G. Yamada. (Received from K. Togashi). (Fig. 1, E).

Type material in Mycological Herbarium, University of Kansas.

This fungus differs from the European *Taphrina bullata* on *Pyrus communis* L., in that the ascus lacks a stalk cell. It is morphologically similar to *Taphrina piri* Kusano, a Japanese species occurring on *Sorbus alnifolia* K. Koch (*Pyrus miyabei* Sarg.). The hosts, however, do not seem to be closely related.

5. *Taphrina padi* (Jacz.) sp. nov.

Taphrina pruni Tulasne, Ann. Sci. Nat. 5 ser. Bot. 5:122-126. 1866. In part.

Taphrina pruni Tul. var. *padi* Jaczewski, Pocket Key for Determination of Fungi. Part I. Exoascales. Leningrad. 1926.

Asci clavati sunt, apice rotundati, 26-46μ longi × 8-13μ lati. Cellulae basilares variae sunt, interdum basi latiores, 8-26μ longae × 7-10μ latae. Ascospori elliptici sunt, 5-6μ × 4.5μ, in asco frequenter germinantes. Fructus *Pruni padi* L. deformat et eos in "sacculos" mutat.

Asci are clavate, rounded at the apex, 26-46μ × 8-13μ. Stalk cells are variable, sometimes wider at the base, 8-26μ × 7-10μ. Ascospores are elliptic, 5-6μ × 4-5μ, often budding in the ascus. Deforms fruits of *Prunus padus* L. transforming them to "pockets". Experimentalfältet, Stockholm, Sweden, July 5, 1939, C. Hammarlund. (Fig. 1, D).

Type material in Mycological Herbarium, University of Kansas.

This species has long been included in *Taphrina pruni* Tul. which causes fruit "pockets" on *Prunus domestica* L. The two hosts are not closely related and the fungi are morphologically distinguishable, *Taphrina pruni* having asci 17-53μ × 5-17μ; stalk cells 5-27μ × 4-13μ. Jaczewski (l.c.), recognizing these differences, made the fungus on *P. padus* a variety of *T. pruni*. It is believed that *Taphrina padi* is more closely related to *T. farlowii* Sadeb. and to *T. confusa* (Atk.) Gies. than to *T. pruni*.

6. *Taphrina thomasii* sp. nov.

Asci hypophylli sunt, ex chlamydosporis emergentes, clavati, apice rotundati, 20-35μ longi × 6-10μ lati. Cellulae basilares paulo variae sunt, per occasionem bifurcae, 8-16μ × 6-8μ. Interdum illae desunt, et tum asci 32-38μ longi sunt. Ascospori globosi aut elliptici sunt, in asco frequenter germinantes, 4-7μ × 4-5μ.

"Scopas sagarum" in ramis *Pruni ilicifoliae* Walp. gignit.

Asci are hypophyllous, emerging from chlamydospores, clavate, rounded at the apex, 20-35μ × 6-10μ. Stalk cells are somewhat variable, occasionally forked, 8-16μ × 6-8μ. Sometimes they are lacking and then the asci are 32-38μ long. Ascospores are round or elliptic, 4-7μ × 4-5μ.

Causes witches' brooms on branches of *Prunus ilicifolia* Walp. (Fig. 1, G).

Los Altos, Santa Clara Co., California, 1943. H. Earl Thomas.

This species, named in honor of its collector, resembles *Taphrina cerasi* (Fkl.) Sadeb., which causes witches' brooms on *Prunus avium* L. and *P. cerasus* L. These hosts, however, are not closely related to *P. ilicifolia.* The latter, known as "Islay", is an evergreen cherry belonging to the section *Laurocerasus* of the genus *Prunus.*

Distinguishing features of *Taphrina thomasii* are the manner in which the young ascus breaks out of the chlamydospore leaving the wall of the latter persisting around the base of the ascus, and the fact that the stalk cell is cut off late so that occasional mature asci may be found lacking stalk cells.

7. *Taphrina darkeri* sp. nov.

Asci amphigeni sunt, late cylindrati, apice rotundati aut truncati, 16-33μ longi × 8-13μ lati. Cellulae basilares breves sunt, frequenter latiores quam asci, 5-12μ alti × 10-17μ lati. Ascospori globosi aut elliptici sunt, 4-4.5μ × 3.5-4μ.

Maculas parvas brunneas mortuas in foliis *Aceris circinati* Pursh. gignit.

Asci are amphigenous, broadly cylindric, rounded or truncate at the apex, 16-33μ × 8-13μ. Stalk cells are short, often wider than the asci, 5-12μ × 10-17μ. Ascospores are round to elliptic, 4-4.5μ × 3.5-4μ. (Fig. 1, H).

Causes small brown necrotic spots on leaves of *Acer circinatum* Pursh.

Head of Limestone Creek, Oregon Caves, Oregon, Aug. 15, 1929, G. D. Darker (Herb. Arnold Arboretum 5077).

Type material in Mycological Herbarium, University of Kansas.

Most species of *Taphrina* on *Acer* are morphologically very

much alike. They are distinguishable by small differences in ascus-size and by host relations. So far as they are known they seem to be biologically specialized and in most cases the forms on different species of *Acer* have been held to be separate species. In accord with this procedure the fungus on *Acer circinatum* is considered new and is named in honor of its collector.

A Persistent Left Superior Vena Cava in the Dog

O. O. STOLAND and HOMER B. LATIMER
Departments of Physiology and Anatomy, University of Kansas.

Many cases of persistent left superior vena cava have been reported in the literature for man. As a rule, these persistent left superior venae cavae empty into the coronary sinus and from thence into the right atrium. This type of anomaly has been discussed in so many of the preceding articles and in the texts (for example, Patton, 1946) that no further discussion of its embryological origin will be attempted in this report.

There are two outstanding reviews of the literature on persistent left venae cavae. The first was that of McCotter (1917) who listed 117 cases published up until this date and then he added three new cases which he had seen, thus making a total of 120 cases reported up to that time. The second careful study of the literature was made in 1939 by Chouke. He found six additional cases not listed in McCotter's bibliography and then added 79 more cases which had appeared in print since McCotter's paper, including one additional case of his own, thus making a total of 205 cases in 1939. Since the publication of Chouke's paper we have found one report of two additional cases (Prows, 1943) thus bringing the total to 207 cases. The bibliographies of both McCotter and Chouke are so carefully prepared that it has not seemed necessary to review the literature again.

All but three of these 207 cases have been found in man. Grant in 1917 reported one case found in a cat, and there are two cases for the dog. A persistent left superior vena cava was described in a dog by Bradley in 1902 and another by Harris in 1921 (quoted from Chouke). In Bradley's report, he comments on the number of cases then described in man and he says that he was not able to find a single case of persistent left superior vena cava reported for the dog.

An anomaly as evident in this should have been seen in some of the laboratory animals as frequently as in man. Very likely, there are more cats and dogs dissected than human cadavers, and it seems as though this should have been seen and recognized at least as frequently as in man, that is of course, if it does occur as frequently in these animals as in man. It is possible that many experiments are made on these animals which do not bring this part of the anatomy

into view and so this anomaly is not recognized. We would hesitate to add additional cases to an existing list of 207 cases, if any appreciable number of them had been reported from dogs. Since there have been but two cases reported previously in dogs, it seems wise to call attention to this case occurring in a dog, although the case is very similar anatomically to many already described in man.

The senior author has been studying the coronary circulation for some time, and in a series of at least 200 dogs used in these experiments, he has seen two cases similar to the present case. Neither of these was published. Also, Kenneth E. Jochim of the physiology department of the University of Kansas, tells us that he has seen two similar cases, also not published. Thus we are able now to add five more cases of persistent left superior vena cava found in the dog to the list of only two reported up until this time.

This persistent left superior vena cava was found in a dog heart which was being prepared for a heart-lung preparation. Nothing unusual was noticed until the cannula was introduced into the coronary orifice and then the unusually large opening was discovered and then, the greatly enlarged coronary sinus. Next the large vein, or the persistent left superior vena cava, opening into the coronary

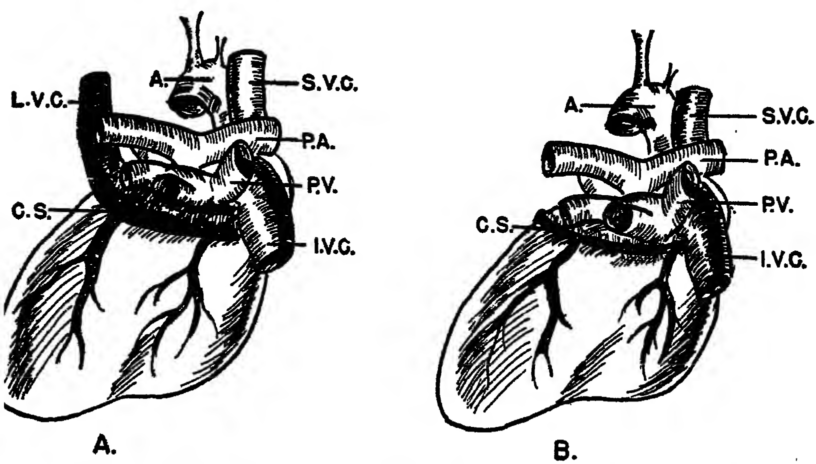


Figure 1.—Drawing made from the posterior and slightly from the right to show, in Panel A, the heart with the persistent left superior vena cava, and in Panel B a normal heart drawn from the same view.

A. —aorta
C. S. —coronary sinus
I. V. C.—inferior vena cava
L. V. C.—persistent left superior vena cava
P. A. —pulmonary arteries
P. V. —pulmonary veins
S. V. C.—superior vena cava

sinus was seen. The heart and the attached lungs were then preserved intact. Unfortunately the large vessels leading to and away from the heart of this dog were not saved, for nothing of this character was suspected until the heart and lungs had already been removed from the dog.

This case seems to be much like many of the cases of persistent left superior vena cava described in man. The drawing in figure 1 shows the heart with the persistent left superior vena cava to the left in panel A and a heart with normal vessels is shown to the right in panel B. Both hearts are drawn to the same scale and from the same view, or from the posterior and slightly from the right side. In the anomalous heart, (Panel A) the persistent left superior vena cava (L. V. C.) is shown descending and opening into the greatly enlarged coronary sinus (C. S.) which opens in a normal manner into the right atrium. This opening of the coronary sinus was greatly enlarged, of course, but in a perfectly normal position. A small vein was seen connecting the two superior venae cavae above the base of the heart. This vein is not shown in the drawing. This vessel instead of developing into the left innominate vein had remained as a very small vessel in this dog. The right superior vena cava appeared to be somewhat smaller than normal for a heart of this size. So far as we could determine, the other veins, or the inferior vena cava and the pulmonary veins, were normal in size and position, and likewise the aorta and the pulmonary arteries, were perfectly normal. The dog was a large and healthy specimen, so this abnormal retention of a part of the fetal circulation had in no way affected his development.

We are reporting this case together with the four similar cases hitherto unreported, for it seems that this anomaly should be looked for in the studies of the dog, to determine whether it does occur as frequently as in man or whether it has just been overlooked in most of the studies on the dog and cat.

References

BRADLEY, O. C. 1902. A case of left anterior (superior) vena cava in the dog. Anat. Anz., 21, 142-144.

CHOUKE, K. S. 1939. A case of bilateral superior vena cava in an adult. Anat. Rec., 74, 151-157.

GRANT, S. B. 1917. A persistent superior vena cava sinistra in the cat transmitting coronary blood. Anat. Rec., 13, 45-49.

HARRIS, H. A. 1921-25. Persistent left superior vena cava in a dog. Proc. Anat. Soc. Gt. Brit. and Ireland, p. 59 (Quoted from Chouke).

McCOTTER, R. E. 1916. Three cases of persistence of the left superior vena cava. Anat. Rec., 10, 371-383.

PATTON, B. M. 1946. Human embryology. The Blakiston Company, Philadelphia.

PROWS, M. S. 1943. Two cases of bilateral superior venae cavae, one draining a closed coronary sinus. Anat. Rec., 87, 99-106.

The Diffusion of Organic Dyes in Gelatin Gel

ORLAND W. KOLLING and P. DANIEL SCHULTZ
Friends University, Wichita.

In studying the diffusion of solutions in colloidal gels, the use of organic dye solutions offers two advantages: first, their pronounced colors facilitate the visual measurement of their progress through the gel; and second, their ionization is either acid or basic. The amphoteric nature of a protein gel could be expected to be an accelerating factor for such dissociation of the solution.

A seven and one-half per cent gelatin gel was prepared by dissolving the dry gelatin in hot water, adding a tiny thymol crystal to the mixture to prevent possible bacterial action. The solution was poured into tubes of 8 mm. inside diameter. The tubes were filled to a height of two inches and the gel formed upon cooling to room temperature. After allowing the gel to stand twenty-four hours, the lower surface of the upper meniscus was marked and 1 cc. of a one-tenth per cent water solution of the dye was placed on the gel surface. A set of four tubes was used for each dye, the average for each set being given in the table. A temperature range of 25-26° C. was maintained throughout the experiment, and the progress of the dye was measured visually by 0.1 mm. Vernier calipers, with the aid of a lens and a strong beam of light. The total distance diffused for each dye was recorded in the table at the end of each half hour for a four hour period.

Table of Diffusion Rates of the Dyes

Dye and Molecular Weight	½ hr.	1	1½	2	2½	3	3½	4
Acid Dyes								
Benzopurpurin 4B (M.W. 725)	0.5	0.7		1.0		1.1		1.3
Erythrosine salt (M.W. 880)	1.0	1.4	1.7	2.0	2.2	2.4	2.6	2.8
Metanil Yellow (M.W. 375)	1.8	2.4	2.9	3.5	3.9	4.1	4.4	4.9
Basic Dyes								
Methylene Blue (M.W. 301)	1.7	2.8	3.6	4.2	4.8	5.4	5.9	6.8
Orange II (M.W. 375)	1.7	2.3	2.7	3.3	3.7	4.0	4.3	4.7
Rosaniline Hydrochloride (M.W. 338)	3.1	4.0	4.9	5.7	6.3	6.9	7.4	8.0
Sodium salt of Eosin (M.W. 692)	1.6	2.2	2.6	3.1	3.7	3.9	4.6	5.2

The diffused distances are expressed in millimeters.

In examining the diffusion rates of the seven dyes used, it is readily noted that those dyes having higher molecular weights dif-

fuse much more slowly than those of lower molecular weights. From the low diffusion rate of Benzopurpurin 4B, one would tend to conclude that higher aggregates than the simple molecule exist in the solution.

A comparison of dyes of similar molecular weights reveals that the basic dyes definitely diffuse more rapidly than the corresponding acid dyes, with the exception of Metanil Yellow whose behavior may be attributed to the possible presence of other salts, since the sample used was of technical grade of purity. Brown and Reid,[1] using buffered gels, found a similar behavior for basic dyes as compared with acid. This might be explained by the effect noted by Mommsen,[2] that in diffusion dyes into gels of different pH values, acid dyes diffuse more readily in less acid media and basic more readily in less basic solutions. However, since the gelatin used behaved neutrally toward indicators and no color change resulted in those dyes diffused that are indicators, it is the opinion of the author that the effect is not attributable directly to a definite acid condition of the gel in this case. It is believed that a more accurate explanation would consider that the amphoteric property of the protein gel reacted more strongly toward the basic dyes than toward the acid in the presence of the diffusion dye.

Bibliography

Brown, Frances C., and Reid, E. Emmet, "The Diffusion of Dyes in Ethylene Glycol Gels", Journal of Laboratory and Clinical Medicine, vol. 28, No. 9, p. 1098-1103 (1943).

Mommsen, H., "Ueber den Einfluss der Wasserstoffionen Konzentration auf die Diffusion von Farstoffen in eine Gelatine gallerte", Biochem. Ztschr. 168, 77, (1926).

[1]Brown, Frances C. and Reid, E. Emmet, "The Diffusion of Dyes in Ethylene Glycol Gels", Journal of Laboratory and Clinical Medicine, vol. 28, No. 9, p. 1101 (1943).

[2]Mommsen, H., "Ueber den Einfluss der Wasserstoffionen Konzentration auf die Diffusion von Farbstoffen in eine Gelatine Gallerte", Biochem. Ztschr. 168; 77, (1926).

Structure and Convergence of the Formations in the Lansing Group, Wilson County, Kansas*

J. R. CHELIKOWSKY
Kansas State College, Manhattan
and
VIRGIL BURGAT
Regional Geologist, State Highway Commission, Topeka

Introduction

The area discussed lies in the southern half of Wilson County between the towns of Fredonia and Altoona (Fig. 1A). It is approximately four miles long and two miles wide and is traversed from west to east by highway K47.

The field work on which the paper is based was part of a survey conducted for the State Highway Commission along highway K47. The very rapid convergence of certain formations encountered during the survey led to a more detailed study of that portion of the area in which the convergence was most pronounced.

The purpose of the study was (1) to gain an understanding of the conditions that existed during sedimentation, (2) to determine whether there was any relationship between the convergence and the location of the folds, and (3) to determine whether the folds were the result of compressive forces, or simply the result of normal sedimentation.

Stratigraphy and Geologic Setting

The outcropping formations are all of Pennsylvanian age and include the Lane-Bonner Springs shale, the Plattsburg limestone, the Vilas shale, and the Stanton limestone of the Missouri series and the Tonganoxie channel sandstone of the Virgil series (Fig. 2D). The Tonganoxie sandstone is in contact with the Plattsburg limestone south of highway K47 and is stratigraphically lower here than previously reported elsewhere (Moore, Frye, and Jewett, 1944, pp. 184, 198; Moore, 1936, p. 149). The occurrence of the sandstone is very spotty and no attempt was made to map its distribution.

The Captain Creek limestone is the only member of the Stanton limestone formation that occurs in the area. All of the members that normally overlay it have been eroded away. Much, if not all,

*Published with the permission of S. E. Horner of the State Highway Commission, Topeka, Kansas.

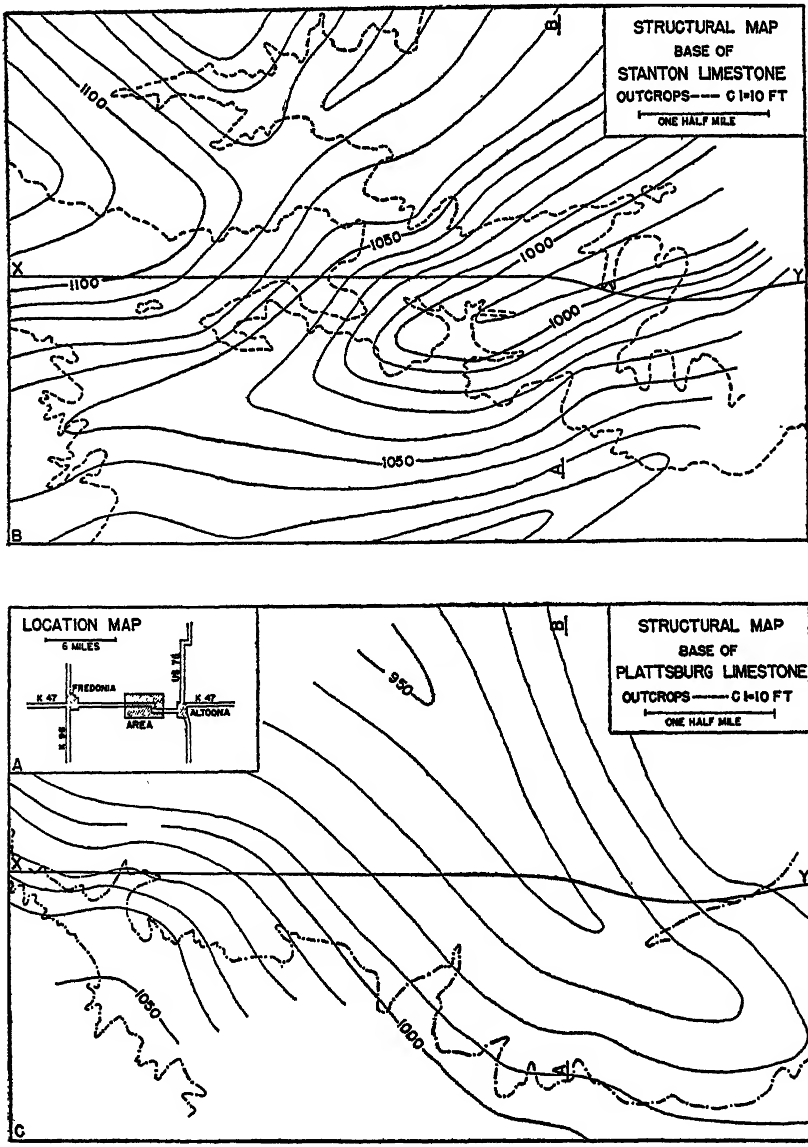


FIGURE 1

of this erosion occurred prior to the deposition of the Tonganoxie sandstone. The bold scarp about three miles west of Altoona to the north of K47 is the Captain Creek limestone.

The Captain Creek scarp is most pronounced wherever the Vilas shale is the thickest. Where the Vilas shale thins out, the

Plattsburg limestone formation and the Captain Creek limestone member join to make essentially one thick limestone unit. Since the maximum depth of erosion in such areas was generally but slightly more than the combined thickness of the Plattsburg and Captain Creek limestone no scarp could develop. In these scarp-free areas

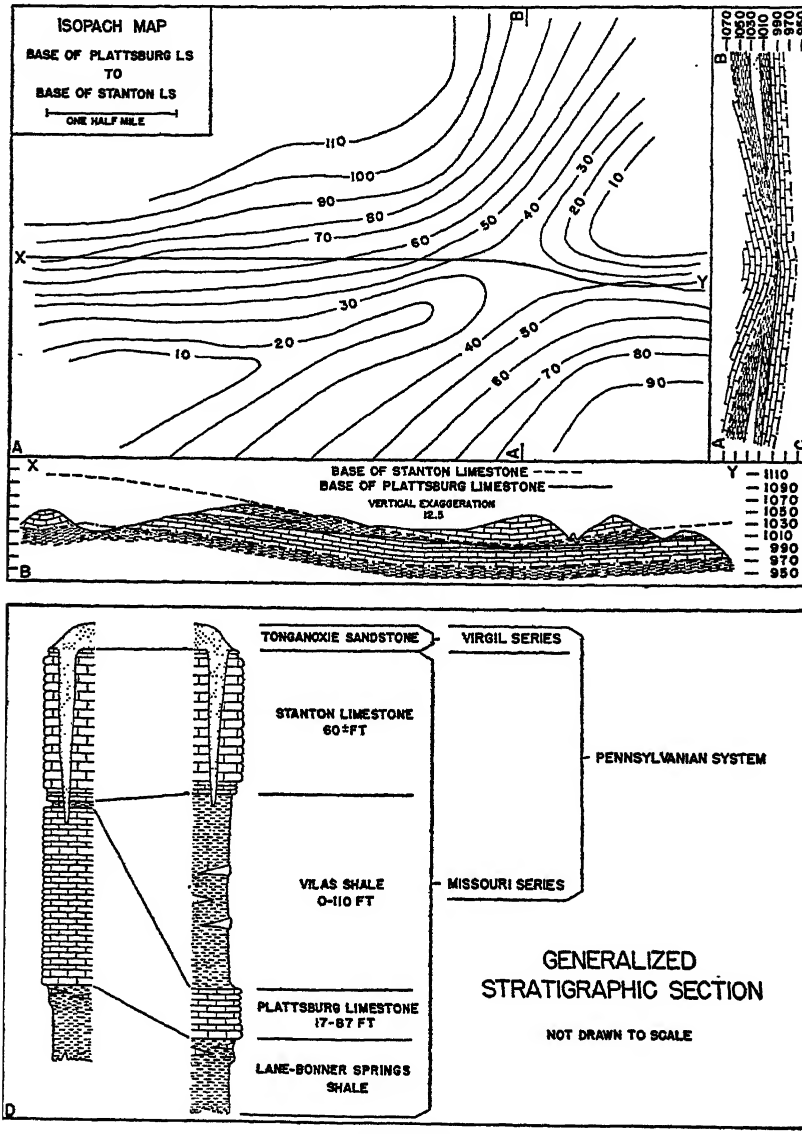


FIGURE 2

the hills are of a rolling character. The topography with its distribution of scarps and rolling hills is, in effect, a reflection of the disposition of the Vilas shale.

Wherever the Vilas shale is thick, sand lenses appear near the middle of the formation whereas where the shale is thin, the sandy facies disappear. The formation varies from a thin calcareous parting between the Plattsburg and the Stanton limestone formations to a formation more than a hundred feet thick.

According to Moore (1936, pp. 35-37), the sediments of the Missouri epoch were derived from the south because when traced into Oklahoma the limestones give way to shales and sandstones. Sea level fluctuated considerably throughout this epoch as indicated by well developed cyclothems (Moore, 1936, p. 34). During the shallow water phases coarse sediments were probably swept by relatively fast currents over a gently sloping equilibrium surface into lagoonal-like basins. There, the previously deposited fine sediments were gradually overlapped. During the deeper water phases, however, the process was reversed with the finer sediment of the lagoon gradually spreading outward over the old equilibrium surface and the previously deposited coarser sediments. Such a depositional environment seems to fit the local conditions.

Structure and Convergence

In order to determine whether there is any relationship between folding and convergence, structural contours were drawn on the base of the Stanton and Plattsburg limestones. An isopach map based on the interval between these two datums was constructed from these maps so that a comparison could be made between the location of the folds and the areas of minimum and maximum interval thickness (Fig. 2A). A study of all three maps reveals the following relationship:—(1) The structure in the Stanton does not coincide with the structure in the underlying Plattsburg. The Stanton structure is a syncline trending NE-SW whereas the Plattsburg structure, which is also a syncline, trends NW-SE. The pitch of the Stanton syncline is to the NE, but the pitch of the Plattsburg is to the NW. (2) The upper, or Stanton syncline, is much sharper in form than the lower, Plattsburg, syncline. The steepest dip of the Stanton is 140 feet per mile, and its steepest pitch is 80 feet per mile. For the Plattsburg the steepest dip is 70 feet per mile, and its steepest pitch 25 feet per mile. (3) The interval thickness (top of Vilas to base of Plattsburg) increases to the NW and SE from the point where the two synclinal axes cross, and decreases to the

NE and SW (Fig. 2A). It should be pointed out, however, that the Vilas shale and the Plattsburg limestone do not converge in the same direction. The relationship is inverse. In other words, the direction of thickening for one is the direction of thinning for the other. This information was gained from numerous sections that were measured in the field. It is shown as accurately as possible in the profile along the line X-Y (Fig. 2B) and in a general way in the cross section along the line A-B (Fig. 2C). Since the rate of thickening of the Vilas shale is much greater than the rate of thinning of the Plattsburg, the isopach map's characteristics are dominated by the Vilas convergence factor. Hence, the map shows the direction of Vilas convergence, but not the rate. The shale thickness to the NW and SE and thins to the NE and SW. These directions are given from the point where the two synclinal axes cross. (4) Along the Stanton synclinal axis the Vilas shale is very thin or entirely absent so that the Captain Creek rests essentially on the Plattsburg. (This synclinal axis extends south eastward and takes in the area of the "cement" quarry south of Fredonia). (5) The Vilas shale thickens very rapidly to the NW and SE of the Stanton synclinal axis which is in the direction of the two flanking anticlinal structures.

Interpretation of the Structural Pattern

A study of the structural pattern makes clear that the effect could not have been produced by tectonic forces for it is inconceivable that compression could have produced two synclines at right angles to each other. Even if two separate periods of compression are considered, a tectonic explanation would give rise to considerable difficulty. It would be exceedingly difficult to explain how a Stanton syncline which is much sharper than the Plattsburg syncline could be formed without wiping out the effect of the previous milder deformation. Then too, the resolution of forces acting on the upturned layers of Plattsburg into compressive forces to form the Stanton syncline would be impossible. It is a well established fact that in compression newer folds are generally localized over older folds. Finally, the absence of an unconformity between the two limestones nullifies any consideration of two separate tectonic movements.

Since the tectonic explanation is apparently wanting, the answer to the problem must be sought for in an analysis of the sedimentary data. There are several significant details that should be emphasized:—(1) The inverse convergence relationship between the Vilas shale and the Plattsburg limestone, (2) the appearance of a

sandy phase in the Vilas shale wherever that formation thickens and (3) the thickening of the Vilas shale away from the Stanton syncline toward the flanking anticlines.

The fact that the Plattsburg limestone thins wherever the Vilas shale thickens is apparently an indication that the two formations are genetically related. If this is true, the thick areas of Plattsburg limestone probably represent localities where the Vilas shale developed into a limestone facies, a relationship probably true also for the Stanton. An ideal site for the development of such conditions would be a sheltered lagoonal-like basin.

The appearance of a sandy phase in the Vilas shale indicates a period of stronger currents and probably shallower water conditions than those which initiated and closed the period of sedimentation, or stated in another way, the Vilas represents a depositional environment which varied from relatively deep to shallow water conditions (overlap). It is recognized that the sandy phase could also result from variations in current alone, by deposition in a stationary sea, or from a combination of current and sea level fluctuations. However, the effect would be the same.

The thickening of the Vilas shale away from the Stanton synclinal axis toward the flanking anticlines together with the fact that as the Vilas shale thickens, sandy phases appear, would seem to indicate that the structures in the Stanton are the result of a combination of normal sedimentary processes and differential compaction. The relatively more sandy phase of the Vilas shale could not compact as much as the finer textured phase of clay and calcareous ooze. Therefore since the Stanton synclinal area was one of essentially calcareous ooze, and the anticlinal areas one essentially of sand and sandy shale, differential compaction of the two areas accounts

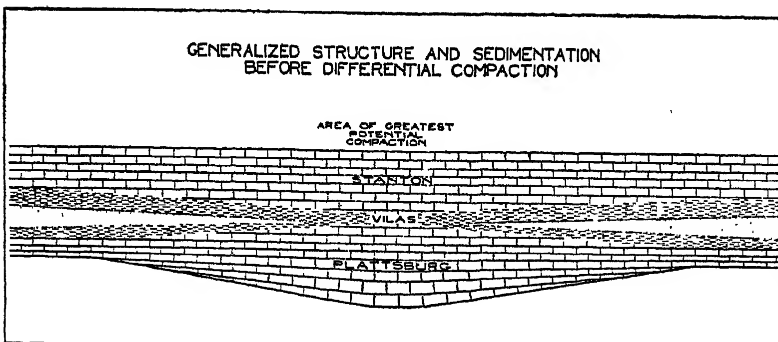


FIGURE 3

for the structures as they appear. Figure 3, a cross section at right angles to the Stanton syncilnal axis, is intended as a diagramatic explanation of the stratigraphic conditions that existed prior to differential compaction.

Conclusions

Studies based on field work and an analysis of the isopach map indicate that the structure of the area is stratigraphic in origin. Tectonic forces other than those responsible for fluctuations in sea level were non-existent or too feeble to leave any recognizable effects. It is believed that during the last phase of Plattsburg deposition, a lagoonal-like basin existed whose axis coincided essentially with that of the present Stanton syncline. The shape of the lagoon was similar in configuration to the form shown by the isopach lines in Figure 2A. Along the axis of the lagoon quiet water conditions permitted the deposition of fine calcareous oozes and toward its margins, where shallower water and stronger currents prevailed, coarser sediments of the same age were deposited. As the water became shallower, and the currents stronger, the coarser textured muds encroached over the calcareous oozes and at the edges of the lagoon, sand gradually spread inward over the muds. This brought to a close the offlap phase of deposition, and completed the Plattsburg facies of the Vilas shale. In the next, overlap, phase there was a general subsidence and consequent reversal in the direction of sedimentation. The calcareous ooze at the center of the lagoon spread over the marginal muds which in turn spread over the previously deposited sands. This condition prevailed until the whole area was finally blanketed under a calcareous cover (Fig. 3). This phase of deposition began with the Stanton facies of the Vilas and ended with a complete overlapping of the Vilas by the Stanton. Sediments that were subsequently deposited helped to bring about the differential compaction that was instrumental in bringing about the final structure.

The writers are of the opinion that most of the smaller structures and perhaps some of the larger ones in the state have had a similar origin. In view of the fact that the smaller structures are becoming increasingly more important in prospecting for petroleum because the larger, and more obvious structures, have already been exploited, exploration work should include a careful investigation as to the cause of the structure. If the origin is similar to the one just described, structural mapping of a surface key will not of itself be of much value.

References

MOORE, R. C., 1936, Stratigraphic classification of the Pennsylvanian rocks of Kansas: Kansas Geol. Survey, Bull. 22, pp. 1-256, figs. 1-12.

MOORE, R. C., FRYE, J. C., and JEWETT, J. M., 1944, Tabular description of outcropping rocks in Kansas: Kansas Geol. Survey, Bull. 52, pt. 4, pp. 137-212, figs. 1-9.

The Seventy-Ninth Annual Meeting

The seventy-ninth annual meeting of the Kansas Academy of Science was held at the University of Kansas, Lawrence, Kansas on April 2 and 3, 1947, with Dr. Claude W. Hibbard, formerly of the University of Kansas, now of the University of Michigan, presiding. The Kansas Entomological Society, which is affiliated with the Academy, held its twenty-third annual meeting on April 3. The Kansas chapter of the American Association of University Professors held its meeting in cooperation with the Academy. The mathematical groups held their meeting this year at Wichita.

From the Senior Academy 242 registered and an estimated attendance of 180 was reported from the Junior Academy. A section meeting in psychology was held Wednesday afternoon, and an Open House on Mineral Resources was held in Lindley Hall at the same time, the first general meeting was a business meeting, at which reports of officers were made and an amendment proposed to the constitution. A second Open House, this time at the Museum of Natural History in Dyche Hall, occupied the evening.

Sectional meetings were held Thursday morning and afternoon. Reports from the section chairmen will be found in Table 1. At 11 a.m., the address of the retiring president, Dr. Claude W. Hibbard, was given. It was entitled: "Pleistocene Vertebrate Faunas of Kansas." Dr. Hibbard has been studying this subject for many years. The final business meeting and a brief meeting of the new Council were held Thursday afternoon, both of which will be reported in full in the Transactions.

The annual banquet was held Thursday evening with the new president, Dr. J. C. Peterson of Kansas State College, as toastmaster. The various officers and several others were introduced. A spirited address of welcome was given by Chancellor Deane W. Malott of the University.

The reports of the section chairmen follow in Table 1. The next meeting will be held at Pittsburg, Kansas, in the spring of 1948.

Table 1.

Name of Section or Organization	Chairman for 1947	No. Papers on Program	No. attending	Chairman for 1948
Botany	O. R. Clark	21	59	Theodore M. Sperry
Chemistry	O. W. Chapman	5	35	John Davis
Geology	J. M. Jewett	18	46	Frank Byrne
Junior Academy Science	Ralph Rogers	—	180	Ralph Rogers
Kansas Entomological Society	J. C. Frankenfeld	25	55	Fred D. Butcher
Physics	J. D. Stranathan	9	47	W. H. Matthews
Psychology	J. C. Coleman	11	35	Paul Murphy
Science Teachers	Guy B. Homman	4	35	Margaret Parker
Zoology	D. S. Farner	16	45	Claude Leist

The public address entitled: "Pre-History and the Missouri River Basin Development Program" was given by Dr. Waldo Wedel of the United States National Museum, Friday evening.

The following officers were elected for 1947-1948:

President, Dr. J. C. Peterson, Kansas State College:

President-elect, Dr. F. W. Albertson, Ft. Hays Kansas State College;

Vice President, Dr. Paul G. Murphy, Kansas State Teachers' College at Pittsburg;

Secretary, Dr. Frank C. Gates, Kansas State College;

Treasurer, Prof. S. V. Dalton, Ft. Hays Kansas State College;

Additional Executive Council members:

Dr. A. B. Leonard, University of Kansas;

Dr. P. S. Albright, University of Wichita;

Mr. A. C. Carpenter, Ottawa;

Librarian, Dr. D. J. Ameel, Kansas State College;

Editor, Dr. Robert Taft, University of Kansas (Term expires 1950);

Associate editor (Geology), Dr. W. H. Schoewe, University of Kansas (Term expires 1950);

Associate editor (Botany), Dr. F. C. Gates, Kansas State College (Term expires 1950).

The official program as revised is given below.

FRANK C. GATES, *Secretary.*

PROGRAM OUTLINE

Wednesday, April 2

10:00 a.m. Executive Council Meeting, Room 226, Snow Hall.
12:00 m. to 3:00 p.m. Registration, Lindley Hall.
2:00 to 4:00 p.m. Section Meeting. Psychology, Room 9, Frank Strong Hall.
2:00 to 4:00 p.m. Open House, Mineral Resources, Lindley Hall.
4:15 p.m. General Business Meeting, Room 426, Lindley Hall, President Claude W. Hibbard, presiding.

1. Announcements.
2. Reports of recipients of 1946 research awards.
3. Reports of Academy officers and committees.

7:30 to 8:30 p.m. Open House, Museum of Natural History, Dyche Hall.

Thursday, April 3

8:30 to 10:30 a.m. Sectional meetings.
Botany, Room 417, Snow Hall.
Chemistry, Room 201, Bailey Chemistry Laboratories.
Geology, Room 402, Lindley Hall.
Physics, Room 210, Blake Hall.
Psychology, Room 9, Frank Strong Hall.
Zoology, Room 206, Snow Hall.
9:00 a.m. to 12:00 m. Registration, Junior Academy, Room 108, Bailey.
9:00 to 10:00 a.m. Registration, Kansas Entomological Society, Room 323, Snow Hall.
10:00 a.m. Business meeting of K. Entomological Society, Room 101, Snow Hall.
11:00 a.m. Presidential Address, "Pleistocene Vertebrate Faunas of Kansas." Dr. Claude W. Hibbard, Museum of Paleontology, The University of

Michigan, Ann Arbor, Michigan, Room 426, Lindley Hall.

12:00 m. Luncheon A.A.U.P. members, Union Cafeteria.

1:00 to 4:00 p.m. Junior Academy, 301 Bailey Chemistry Laboratories.

1:00 to 3:00 p.m. Sectional and Affiliated Meetings.
Botany, Room 417, Snow Hall.
Chemistry, Room 201, Bailey Chemistry Laboratories.
Entomology, Room 101, Snow Hall.
Geology, Room 402, Lindley Hall.
Physics, Room 210, Blake Hall.
Psychology, Room 9, Frank Strong Hall.
Science Teachers, Room 502, Snow Hall.
University Professors, English Room, Union Building.
Zoology, Room 206, Snow Hall.

3:15 p.m. General Business Meeting, Room 426 Lindley Hall, President Claude W. Hibbard, presiding.
Election of Officers.

4:30 p.m. Brief meeting of 1947 Committees, Room 426, Lindley Hall.

6:00 p.m. Banquet, Ball Room, Memorial Union Building, Dr. John C. Peterson, Kansas State College, Manhattan, Toastmaster.
Greetings, Chancellor Deane W. Malott, the University of Kansas.

8:00 p.m. Public Address, Fraser Hall. Pre-History and the Missouri River Basin Development Program, by Dr. Waldo Wedel, Associate Curator, Division of Archeology, The United States National Museum.

BOTANY

Chairman, O. R. Clark

Thursday, April 3—8:30-10:30 a.m.

1. Botanical Notes for 1946. F. U. G. Agrelius, K.S.T.C., Emporia. 5 min.
2. Prairie Plants in Kodachrome. Theodore M. Sperry, K.S.T.C., Pittsburg. Lantern. 10 min.
3. Kansas Botanical Notes, 1946, Including Species New to the State. F. C. Gates, K.S.C. 5 min.
4. Kansas Mycological Notes: 1946. Stuard M. Pady, E. D. Hansing, and C. O. Johnston, K.S.C. Lantern. 10 min.
5. Stabilization of Prairies in Western Kansas since the drought of 1933-1940. F. W. Albertson, F.H. K.S.C. Lantern. 10 min.
6. Yields and Utilization of Vegetation by Livestock on a Mixed Prairie in West Central Knss. Andrew Riegel, F.H. K.S.C. Lantern. 10 min.
7. Some Effects of Burning Upon a Prairie in West Central Kansas. Harold Hopkins, F.H. K.S.C. Lantern. 10 min.
8. The Composition, Basal Cover, and Yield of a Mixed Prairie in Central Kansas. Byron Blair, F.H. K.S.C. Lantern. 10 min.
9. Effect of Intensity of Utilization Upon Underground Parts of Short Grasses. Farrel A. Branson, F.H. K.S.C. Lantern. 10 min.
10. Pasture Types of Western Kansas in Relation to the Intensity of Utilization in Past Years. Gerald W. Tomanek, F.H. K.S.C. Lantern. 15 min.
11. Root Systems of Burley Tobacco. L. J. Gier, William Jewell College, Liberty, Mo. Lantern. 3 min.
12. Studies on Visual Education Equipment: Screens. L. J. Gier, William Jewell College, Liberty, Mo. Lantern. 5 min.
13. Another Method of Cataloging Bulletins and Reprints. L. J. Gier, William Jewell College, Liberty, Mo. Lantern. 5 min.

Afternoon Session

14. Martynia louisiana Mill: An Anatomical Study. M. W. Mayberry, U. of K. Lantern. 10 min.
15. Flora of Douglas County, Kansas. Ronald L. McGregor, U. of K. 5 min.
16. A Rapid Drier for Herbarium Specimens. W. H. Horr, U. of K. 5 min.
17. Kansas Plants New to Kansas Herbaria, II. W. H. Horr and R. L. McGregor, U. of K. 5 min.

18. Preliminary Studies on artificially induced cold injury in hard winter wheat. John C. Frazier, K.S.C. Lantern. 6 min.
19. Some New Species of Taphrina. A. J. Mix, U. of K. Lantern. 10 min.
20. Observations on Utilization of Esters and their Constituents by Lipolytic Bacteria. Henry J. Peppler, Carnation Company Research Laboratory, Milwaukee, Wis. (By Title.)
21. The Chemical Composition of Forbs in the Native Pastures at Hays, Kansas. Noel R. Runyon, Soil Conservation Service. (By Title.)

CHEMISTRY

Chairman, O. W. Chapman.

Thursday, April 3—8:30-10:30 a.m.

1. The Priestly Centennial—Birthday of a Chemical Career. Sister Mary Grace Waring, Marymount College, Salina. 10 min.
2. Application of the Hofmann Reaction to Some Aromatic Amides. R. Q. Brewster and W. M. Barlow, Kansas University, Lawrence, 8 min.
3. The Diffusion of Organic Dyes in Gelatin Gel. Orland Kolling and P. Daniel Schultz. Friends University, Wichita. 5 min. Lantern.
4. Licensing Chemists and Chemical Engineers. O. W. Chapman, K.S.T.C., Pittsburg. 8 min.
5. Application of the Electronic Theory to Some Simple Organic Reactions. III. C. A. Vander Werf, Kansas University, Lawrence. (By Title.)

GEOLOGY

Chairman, J. M. Jewett

Thursday, April 3—8:30-10:30 a.m.

1. Ground-Water Resources of Kansas. V. C. Fishel, U.S. Geol. Survey, Lawrence. 15 min.
2. Ground Water Available for Flooding Oil Formations in Eastern Kansas. G. E. Abernathy, State Geol. Survey of Kansas, Pittsburg. 10 min.
3. Petrography and Mechanical Analyses of Mantle and Bedrock Material of Central Kansas. Rennie V. Tye, Kansas State Highway Commission, Topeka. Lantern. 10 min.
4. Petrography of the Lincoln "Quartzite." Ada Swineford, State Geol. Survey of Kansas. Lantern. 10 min.
5. Solution Features in some Cretaceous Sandstones in Central Kansas. John C. Frye and Ada Swineford, State Geol. Survey of Kansas, Lawrence. Lantern. 10 min.
6. Disposition of Oil Field Brines in Kansas. Ogden S. Jones, Kansas State Board of Health, Lawrence, Lantern. 15 min.
7. Notes on the Relationship between Dust Storms and Failure of In-soak. B. Ashton Keith, Institute of Sciences, Washington, D. C. 10 min.
8. Early Vertebrates. George M. Robertson, F.H.K.S.C. 10 min.

1-3 p.m.

9. Criteria for Determining Subsurface Structure. Wallace Lee, U.S. Geol. Survey, Lawrence. Lantern. 15 min.
10. Use of Aerial Photographs in Structural Surveying. V. B. Coombs and J. R. Chelikowsky. K.S.C. Lantern. 10 min.
11. Making Ceramic Slag. William B. Hladik, State Geol. Survey of Kansas, Lawrence. 15 min.
12. Fossil Hunting in Northeast Colorado. Claude W. Hibbard, Univ. of Michigan, Ann Arbor. Lantern. 10 min.
13. Problems in Kansas Archaeology. Albert C. Spaulding, U. of K. 15 min.
14. Coal Reserves in Kansas. W. H. Schoewe, State Geol. Survey of Kansas. 10 min.
15. New (?) Fossil Plants from the Campus of Baker University. Arthur Bridwell, Baker U., Baldwin. Lantern. 10 min.
16. The Microfauna of the Permian Florena Shale. F. E. Byrne, K.S.C. By Title.

17. Magnetic Survey of the Bala Intrusive, Riley County, Kansas. R. M. Dreyer, U. of K. By Title.
18. Pliocene and Pleistocene Ventifacts in Western Kansas. H. T. U. Smith, U. of K. Lantern. 10 min.

KANSAS ENTOMOLOGICAL SOCIETY

TWENTY-THIRD ANNUAL MEETING

J. C. Frankenfeld, Pres.; Luther Hoyle, Vice-Pres.;
D. A. Wilbur, Sec.-Treas.

Thursday, April 3

9:00-10:00 A.M.—Registration
10:00 A.M.—Business Meeting
10:30 A.M.—Presentation of Papers

1 Enithares of the World .... George Brooks
2. Some Effects on Wheat Due to the Presence of the Spring Generation of Hessian Fly Phytophaga destructor .... Leonard M. Redlinger
3. The Status of Breeding for Resistance to Insects in Crop Plants. a. Corn to Southwestern Corn Borer. b. Wheat to Hessian Fly .... R. H. Painter
4. Revision of the Genus Pissonotus .... Loy W. Morgan
5. Saldidae of the Western Hemisphere .... Burton Hodgen
6. The Recent Outbreak of the Elm Calligrapha .... Geo. A. Dean
7. Rhagovelia of the Western Hemisphere .... John A. Bacon
8. Biology of Trombiculidae (Acarinida) of Kansas .... Louis J. Lipovsky
9. Insect Pollination of Alfalfa .... R. L. Parker

Thursday Afternoon

1:30 P.M.—Presentation of Papers

10. Revision of the Genus Monomyx .... Edward L. Todd
11. The Malaria Vector and Its Probable Entrance into the Tingo Maria Region of Peru .... Emilio Vialle
12. The Insect Vectors of Tularemia .... Edwin P. Marks
13. Nematodes as a Garden Pest in Kansas .... Harry R. Bryson
14. Taxonomic Revision of Western Hemisphere Nepidae .... Louis C. Kuitert
15. Southwestern Corn Borer Survey in Northern Kansas .... Frank Miller
16. The Belastomatidae of the Western Hemisphere .... D. Warren Craik
17. The Use of Nynol Rubber in Reproducing Insect Larvae .. Roger Mitchell
18. Bioligy of the Corixidae of North America .... William Wellhouse
19. Problems Encountered by a Student in Pest Control .... V. K. Giddings
20. Revision of the Genus Martarega of the World .... Fred Truxal
21. Treatment of Seeds against Subterranean Insect Attack ...... J. O. Hibbard
22. The Biology and Taxonomy of the Family Hebridae ...... T. Wayne Porter
23. Common Hackberry Psyllid Galls in Kansas .... Roger C. Smith
24. Revision of the Genus Aeolopides Caudell .... Herbert S. Wallace
25. The Genus of Leptopteromyia (Asilidae-Diptera) .... D. Elmo Hardy

Final Business

1. Election of Officers

PHYSICS

Chairman, J. D. Stranathan

Thursday, April 3—8:30-10:30 a.m.

1. Effect of Humidity on Starting a Fluorescent Lamp. R. H. McFarland, K.S.C. (10 minutes).
2. Search for Piezoelectric Effect in Permanent Electrets. Laurence Clarke. U. of K. (10 minutes).
3. A Survey in Experimental Optics. Harvey A. Zinszer, F.H.K.S.C. (10 minutes).
4. Partial Pressures in Thermodynamic Systems of Several Components. Boris Leaf, K.S.C. (10 minutes).
5. Specific Ionization Due to Alpha Particles in Solids. F. E. Hoecker and Leland Bohl, U. of K. (10 minutes).
6. Photoelectric Thermionic Properties of Nickel. D. E. Findley, K.S.C. (10 minutes).

7. The Surface Charge Density of Electrets at High Pressures. G. G. Wiseman, U. of K. (10 minutes).
8. Modification of Perkin-Elmer Infrared Spectrometer for Higher Resolution. George Kilian and S. E. Whitcomb, K.S.C. (10 minutes).
9. A Collimator for Testing Binoculars. R. F. Miller, Baker U. (5 minutes).

PSYCHOLOGY

Chairman, J. C. Coleman

Wednesday, April 2—2:00 to 4:00 p.m.

1. Dr. Bert A. Nash. In Memoriam. Edwina Cowan, Wichita.
2. A Study of Homesickness in College Freshmen. J. W. Nagge, K.S.T.C., Emporia. 10 min.
3. Certain Dynamic Aspects of Criminal Behavior. H. D. Remple. U. of K. 15 min.
4. Certification of Clinical and Consulting Psychologists. Panel Discussion. Chairman: A. H. Turney, Director of Guidance Bureau, U. of K.

Thursday, April 3—10:00 to 11:30 a.m.

5. Intelligence Test Results on 240 Hospitalized Epileptics. H. B. Reed. F.H.K.S.C., Hays. Lantern. 10 min.
6. The Use of Self-Evaluation of Test Performance in Clinical and Vocation Prediction. G. S. Klein, The Menninger Clinic. 15 min.
7. New Visual Aids in Psychology. C. H. Haagen, U. of K.

2:00 to 5:00 p.m.

8. A Comparison of Seven Interest Inventories with Respect to Word Usage. E. R. Roeber, Director of Guidance Bureau, K.S.T.C., Pittsburg. 15 min.
9. An Inductive Method of Analyzing Defenses of Self-Esteem. R. R. Holt. Veterans Administration, Winter General Hospital, Topeka. 15 min.
10. Contemporary Trends in Psychology with Some Predictions for the Future. Panel Discussion.
11. Report of Committee on Merging of KPA and KACP and New Constitution. P. G. Murphy, K.S.T.C., Pittsburg. 15 min.
12. Business Session.

SCIENCE TEACHERS (Physical Science)

Chairman, Guy B. Homman

Thursday, April 3—1-3 p.m.

Applications of Infra-Red Spectroscopy
Dr. S. E. Whitcomb, K.S.C., ... 20 minutes
Academic Dovetailing
Dean Rodney W. Babcock, K.S.C., ... 15 minutes
The Unity of Science
Dr. J. S. Hughes, K.S.C., ... 30 minutes
Liquid Air Demonstrations
Department of Chemistry, University of Kansas .... 30 minutes

ZOOLOGY

Chairman, Donald S. Farner

Thursday, April 3—8:30-10:30 a.m.

1. The More or Less Effects of Genes with Special Respect to Lethals. R. K. Nabours, K.S.C. 10 minutes.
2. An Appendix Epiploica Resembling a Vermiform Process. Homer B. Latimer and Alfred H. Hinshaw, U. of K. Lantern. 10 minutes.
3. A Persistent Left Superior Vena Cava in the Dog. O. O. Stoland and Homer B. Latimer, U. of K. Lantern. 10 minutes.
4. Histoligical Study of the Duodenum of the White Rat. L. J. Gier and J. A. White, William Jewell College. Lantern. 8 minutes.
5. The Growth of the Brain and the Cord in the Fetal Dog. Robert L. Corder and Homer B. Latimer U. of K. Lantern. 10 minutes.
6. Spermatogenesis in Pseudacris triseriata. L. J. Gier and C. C. Stirgers, William Jewell College. Lantern. 10 minutes.
7. Some Effects of Paleontologic and Phylogenetic Studies on Vertebrate Taxonomy. George M. Robinson. F.H.K.S.C. 10 minutes.

Afternoon Session—1:30-3:30 p.m.

8. Sight Records of Rare Birds in Eastern Kansas. Ivan L. Boyd, Baker Univ. 8 minutes.
9. A Technique for Trapping Field Mice. John A. White and Don Vroom, William Jewell College. Lantern. 5 minutes.
10. A preliminary Survey and Ecological Study of the Fishes of Spring Creek and South Ninnescah. Alice Elliott, K.S.C. Lantern. 8 minutes.
11. Food Habits of Crater Lake Salamanders. Donald S. Farner, U. of K. Lantern. 10 minutes.
12. Fauna of Clay County, Missouri: II. Mammalia. L. J. Gier and John A. White, William Jewell College. 5 minutes.
13. Paleocene Amphibia. Edward H. Taylor, U. of K. Lantern. 10 minutes.
14. A New Extinct Emydid from the Lower Pliocene of Oklahoma. E. C. Galbraith, U. of K. 8 minutes.
15. Some Features of the Muscular and Skeletal Systems of the Kangaroo Rat. Virgil Mathis. F.H.K.H.S.C. 7 minutes.
16. Notes on Desert Snake Dens. Wilmer W. Tanner, U. of K. (By Title).
17. Atropine Sulfate and the Retention of Fowl Ascarids. J. E. Ackert and D. J. Ameel. K.S.C. 10 minutes.

JUNIOR ACADEMY OF SCIENCE OF KANSAS

Chairman, Ralph Rogers

April 3—1-4 p.m.

Junior Academy of Science Program

Wichita High School East

1. Phosphorescence .... Lysle Davis
2. CO_2 for a Science Club Program .... Don Glasco
3. Demonstrating my Stroboscope .... Bob Pope
4. Photography in Science .... George Wallace and Lorain Valentin
5. Making and Demonstrating power-driven Air Planes .... Jed Wilhite
6. Making Sound Visible .... Loren Keller
7. Making a Telescope Mirror .... John McKinley
8. Jet-Propelled Cars .... Don McKinley
9. Black Light and Tesla Coil .... Burton Scott

Olathe High School

1. Fire Writing .... Jim Oehringer
2. Magic Pictures .... Delores Van Herche, Rosemary Hoskins
3. Burning Water .... Charles Hyer, Quinn Orvan
4. Handkerchief in Alcohol .... Tommy Payne
5. Miniature Volcano .... Dorothy Obermeyer, Christine Allen
6. Cold Fire .... Jack Holland and G. L. Pierce

Lawrence Junior High School

1. Common Rocks and Minerals .... Tommy Ryther
2. Luminescent Paints .... Allen Moore and Harry Elliott
3. Gas Model Airplane .... Gene Smoyer
4. Model Railroading .... Ralph Hayden
5. Crystal Sets .... Pat McCaffrey and Gilbert Baker
6. Simple Radio Receivers and Amplifiers and Public Address System (Tesla Coil, exhibit). .... Norman Wilsen
7. Two-Tube Radio and Power Supply .... Paul Clark
8. Hydroponics .... Jimmy Koch
9. Experimenting with White Rats .... Jimmy Hemphill and Jimmy Sommers
10. Dissecting a Cat .... Kenneth Olsen
11. Stroboscope (Aniline Dyes, Exhibit) .... Tommy Hankins

Clay Center High School

1. Extraction of Alkaloids .... John Lorem
2. Experiments with a ballistic Pendulum .... Elmer Wohler
3. Contrast and Density in Photography .... Lee Sheppeard
4. Photo-Magic .... Neil Peterson and Phil Meyer
5. Halogens .... Harold Curtis
6. Radio .... Kale Gentry

Manhattan High School

1. Lift .... Bill Aye
2. Models and Motors .... Jim Knight
3. Jet Engines .... George Bishop
4. Dyes as Indicators .... John Hughs
5. Phosphorescence .... Glen Shellenbaum
6. Benefits of Model Airplane Building .... Bob Shuss

Junior Academy Awards

Talks

1. John Hughes .... Manhattan
2. Jimmy Hemphill .... Lawrence
3. Kale Gentry .... Clay Center

Demonstration

1. Burton Scott .... Wichita
2. Bob Pope .... Wichita
3. Phil Meyer .... Clay Center

Best Individual

Burton Scott .... Wichita

Best Group as a Whole

Wichita East
Manhattan
Lawrence Jr. High

Best Exhibition Group

Wichita East
Lawrence Jr. High
Independence

A.A.A.S. Award

Burton Scott

Best Exhibit Ind.

Norman Wilson .... Lawrence Jr. High
Jed Wilhite .... Wichita East
Loren Keller .... Wichita East

AMERICAN ASSOCIATION OF UNIVERSITY PROFESSORS

State Meeting, Lawrence, Kansas—April 3, 1947

12:00—1:00 Luncheon, West Room of the University Cafeteria, Union Memorial Building.
Speaker: Chancellor Deane W. Malott, University of Kansas; address on "The University Administration and the A.A.U.P."

1:00—3:00 General Meeting, Old English Room, Union Memorial Building.
Speaker: William J. Argersinger, Department of Chemistry, University of Kansas; Paper on "Dynamic Equilibrium in the Teaching Profession."
Discussions, led by the Chairmen of A.A.U.P. Committees at the University charged with considering:

(a) Faculty Participation in Institutional Government.
F. E. Kester, professor emeritus, Department of Physics
(b) Procedures for Faculty Evaluation
J. W. Twente, professor, School of Education
(c) The Best Utilization of Faculty Talents
A. H. Turney, director, Bureau of Student Guidance
(d) Budgets and Salary Schedules
N. W. Storer, associate professor, Department of Physics.

At the dinner on Wednesday, 2 April, an auxiliary body, the Kansas Central Committee of the A.A.U.P., which has become quiescent during the war, was reorganized. Professor E. E. Bayles, University of Kansas was elected chairman for the coming year. About 65 were present at the luncheon on Thursday and about 40 attended the general meeting.

Transactions
Kansas Academy of Science

Volume 50, No. 2 — September, 1947

Ground-Water Resources of Kansas*

V. C. FISHEL

District Engineer, Federal and State Geological Surveys, Lawrence

In a previous review in this publication (September, 1946) the development of large surface lakes and reservoirs in Kansas was described in some detail. That water below the surface is, in many Kansas localities, a far more important resource than surface water is a fact that we sometimes fail to realize. Methods of determining the extent and suggestions for the conservation of this important source of water are here discussed in language which any reader of these pages should be able to understand. The Transactions *is pleased to present this article as another important contribution to the notable series of articles which have appeared in recent issues on the natural resources of the state and on methods for conserving these resources. The present review has been prepared by the officer in charge of the important public task of determining the location and measuring the extent of these ground water supplies. For further information concerning Mr. Fishel, see page 121.*—The Editor.

The importance of ground water in Kansas is emphasized by the large quantities of water pumped for municipal, industrial, irrigation, and domestic use. More than three-fourths of the public water supplies of Kansas are obtained from wells. In 1946, only 60 out of 381 municipal water supplies in Kansas were utilizing surface waters.

Information concerning the nature and occurrence of ground-water reservoirs in various parts of Kansas has been gathered during many years by geologists of the State Geological Survey of Kansas and engineers of the Division of Water Resources of the Kansas State Board of Agriculture and the Division of Sanitation of the Kansas State Board of Health. Special studies of ground-water development have been made from time to time in certain districts of the state. Cooperative investigations of the ground-water resources of Kansas were begun in 1937 by the Federal Geological Survey in cooperation with these State agencies. These cooperative studies are carried out under the general supervision of Dr. A. N. Sayre,

Transactions Kansas Academy of Science, Vol. 50, No. 2, 1947.

*Published with the permission of the Directors of the United States Geological Survey and the State Geological Survey of Kansas.

Geologist in Charge, Division of Ground Water, Federal Geological Survey; Dr. R. C. Moore, Research Director and Dr. John C. Frye, Executive Director, State Geological Survey of Kansas; Mr. George S. Knapp, Chief Engineer, Division of Water Resources, Kansas State Board of Agriculture; and Mr. Ben L. Williamson, Director, Division of Sanitation and Mr. Ogden S. Jones, Chief Geologist, Oil Field Section, Kansas State Board of Health.

The purpose of the cooperative investigations is to determine the quantity and quality of water available from the underlying water-bearing formations in the various parts of the state; to develop criteria for choosing favorable locations for drilling and digging wells; to determine the chances of increasing the yield with increasing depth of the well; to ascertain the areas capable of supplying large quantities of water for irrigation or industrial development; and to determine the quantity and quality of water available from each aquifer in such areas. It should be emphasized that information regarding the quality of the water is as important as the quantity for in many areas of the state large quantities of ground water are available but it is too highly mineralized for most ordinary uses.

The principal source of ground water is precipitation as rain or snow. The water enters and moves through the soil and unconsolidated rocks through the openings between the sand grains and clay particles, and in harder consolidated rocks, through fractures and joints. Precipitation falling on the surface percolates vertically downward through the earth until it reaches the zone of saturation, below which the pores and openings of the rock are completely filled with water. The upper surface of the zone of saturation is called the water table. Discharge of ground water by evaporation and transpiration, seepage into streams, and from wells and springs is a continuous process so that the ground-water levels are receding except during and immediately following a period of precipitation at which time the ground-water reservoirs may be replenished. For these reasons the water table is not a fixed surface but is continually fluctuating.

The shape and slope of the water table in southwestern Kansas are shown on Figure 1 by means of contour lines drawn on the water table. Each point on the water table along a given contour line has the same altitude. These water-table contours show the configuration of the water surface just as topographic contours show the configuration of the land surface. The direction of movement of the ground water is at right angles to the water-table contour lines—in the direc-

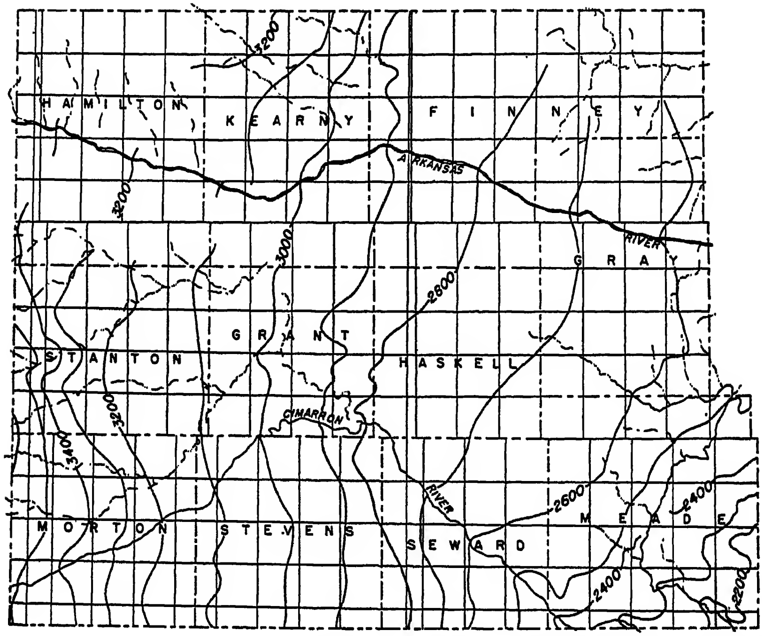


FIG. 1.—Map of southwestern Kansas showing the shape and slope of the water table by means of contours.

tion of the greatest slope. Figure 1 shows that the ground water is moving through southwestern Kansas in a general easterly direction, but that the direction of movement and the slope vary considerably in different directions. The average gradient of the water table in this area is about 10 feet to the mile but it varies from less than 3 feet to the mile to more than 40 feet to the mile. The slope of the water table in general varies inversely with the permeability of the water-bearing material; that is, the water assumes a steeper gradient in flowing through fine material than through coarse material, provided the same quantity of water is moving through both types of material.

In southwestern Kansas the depth to the water level below the land surface is controlled largely by the configuration of the land surface. A map (Figure 2) has been prepared showing the depths to water level in wells by means of lines of equal depths to water level. These lines delimit areas in which the depth to water level lies within specified ranges. The depth to water level in southwestern Kansas ranges from less than 10 feet to about 200 feet. In general the depth to water level is less than 25 feet in the Arkansas Valley and in most

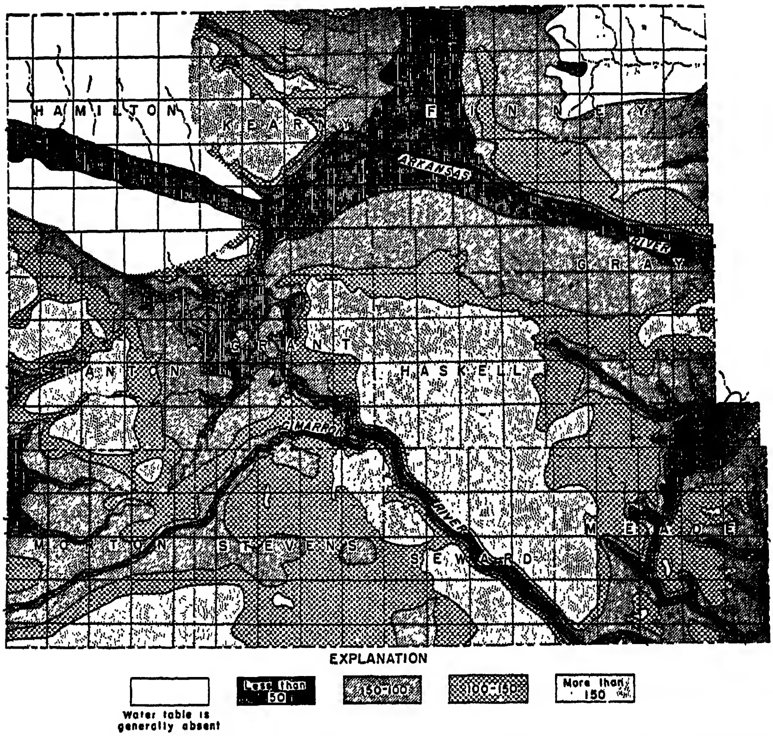


FIG. 2.—Map of southwestern Kansas showing the depth to the water level below land surface.

of the other principal stream valleys and is more than 100 feet beneath the uplands.

The amount of water in a water-bearing formation depends upon the porosity of the rock. Porosity is defined as that percentage of the total volume of the rock that is occupied by pores or other openings. Natural rock materials differ greatly in porosity. The porosity of unconsolidated materials such as sand, clay, and gravel commonly is from 25 to 50 per cent. The porosity of consolidated rocks is much less and is mainly in the joints, fractures, and solution channels.

A rock may have a large porosity and yet yield little water even though allowed to drain for a long time. A clay, for example, with a porosity of 50 per cent, might not yield any water because of the smallness of the pores. The ratio of the volume of water a saturated rock will yield by gravity to the total volume of rock is called the specific yield.

Porosity and specific yield are important properties of an aquifer (a water containing soil or rock), but permeability which is the rate at which water can be transmitted is the most important characteristic. The permeability of an aquifer depends upon the size and arrangement of the pores. In clays the pores are so small that water will be transmitted very slowly. A clean sand of moderate texture will transmit and yield water relatively rapid. In rocks such as granite, slate, schist, some limestone and shale, the water moves along bedding planes, joints, and cleavage planes so that the amount of water such a rock will yield depends on the size and number of these openings.

A very close relationship exists between the geology of an area and the quantity and quality of water that can be obtained from wells in the area. Therefore, an understanding of the fundamentals of geology and the principles of the occurrence of ground water are of great value in estimating the ground-water possibilities of a locality and in choosing the best possible location for drilling.

Much of western Kansas is underlain by the Ogallala formation of Tertiary age. The Ogallala formation consists of thick deposits of calcareous sands, gravels, and sandy clays. Locally these deposits yield large supplies of water for irrigation, industrial, and municipal use. Deposits of sand, gravel, and silt underlie high level terraces along many of the larger stream valleys in the state. In general the terraces represent older, higher stages of the rivers that have since cut their channels deeper and developed new flood plains. The terrace deposits are generally more or less permeable and therefore readily absorb water directly from rainfall and from the run-off from adjacent uplands. Alluvium is the deposit built up by the present streams in their valleys. It resembles terrace deposits in being loosely consolidated and, where coarse, capable of yielding large quantities of water to wells.

Much of north central and eastern Kansas is underlain by consolidated rocks of Cretaceous, Permian, Pennsylvanian, and Mississippian Age. These rocks consist principally of beds of limestone and shale with some sandstone and sandy shales. Locally these older deposits yield abundant supplies of water of excellent quality for stock and domestic use and furnish the municipal supply for many towns. In many areas underlain by these rocks it is difficult to obtain a well water supply of suitable quantity and quality for domestic use. The storage capacity of these rocks is small in comparison with the thick deposits of the Ogallala formation in Western

Kansas. Thus in Kansas the ground-water supplies are meager in the eastern part of the state where the precipitation is fairly high but in Western Kansas where the precipitation is low they are much more plentiful.

The first special project undertaken after the initiation of the cooperative program in Kansas was a careful study of the ground-water area north of Wichita known as the Equus beds. The city of Wichita has also cooperated in the investigation of the Equus beds area. This investigation resulted in the installation of the municipal water supply in 1940 which is drawn from wells located in the southern part of this ground-water reservoir area, about 25 miles northwest of Wichita. In the course of this survey, the geology has been studied from surface outcrops and from artificial exposures, and from 161 test wells that have been put down by the State Geological Survey of Kansas in order to obtain information on the distribution and character of the water-bearing beds. A detailed map of the sloping water table has been prepared to show the direction of movement of the ground water, its relation to surface-water bodies, the areas of discharge and recharge, and the effects of heavy pumping and other conditions. Information as to the permeability or water-transmitting capacity of the deposits has been obtained from laboratory studies of materials obtained in the field and from pumping tests on certain wells, supplemented by examination of the water level in surrounding observation wells.

During the investigation of the Equus beds area, special attention has been given to a study of conditions introduced by escape of oil-field brines from ponds in the neighborhood of wells penetrating the reservoir. A grave danger to fresh-water beds in other parts of Kansas exists in the pollution of the ground-water reservoirs by oil field brines. Brine disposal ponds located in areas of pervious deposits, as in McPherson, Harvey, Reno, and other counties, permit the very saline water to seep downward into the underflow.

Cooperative ground-water investigations have been extended to cover much of southwestern and south central Kansas, and a few areas in northwestern, north central, and eastern Kansas. Areas for which cooperative ground-water reports have been published or are in preparation are shown on Figure 3.

Our studies thus far have been largely centered in south central and southwestern Kansas where relatively large supplies of water are available. A geologist is now being assigned to work exclusively in the eastern part of the state where ground-water supplies are

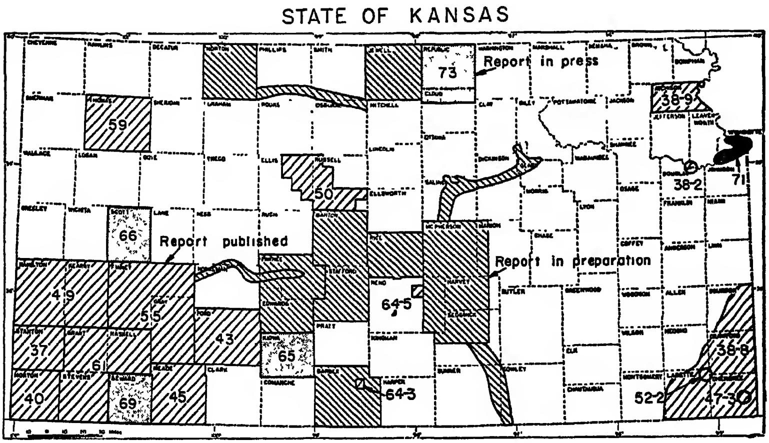


FIG. 3.—Index map of Kansas showing areas for which cooperative ground-water reports have been published by the State Geological Survey of Kansas or are in preparation. Bulletin numbers of reports are shown.

generally meager and satisfactory municipal supplies are difficult to obtain. Our ultimate objective is to make a complete survey of the entire state in which the ground-water conditions in every rock formation and in every locality will be determined. The investigations include the determination of the aquifers that underlie each area, their depth below the surface, thickness, and lithologic and hydrologic properties, the head, temperature, and quality of the water in each aquifer, the quantity of the water that each aquifer will yield for a limited period and perennially, the construction and yield of the wells and their drawdown and interference with other wells.

Practically everywhere that large supplies of water can be obtained from wells the popular belief has developed that the water supply is inexhaustible. This belief in many parts of the United States has led to disastrous over-development. The truth is that the ability of an underground reservoir to yield water over a long period of years is just as definitely limited as that of a surface water reservoir. If water is emptied from an underground reservoir by natural processes and by pumping faster than water comes into it, the supply will be depleted and the water levels in wells will decline and eventually the cost of pumping may become prohibitive, if the supply does not actually fail.

A power company could not safely operate a hydroelectric development without knowing at all times the amount of water enter-

ing the reservoir, the quantity of water in storage, and the quantity being discharged through the turbines or over the spillway. Unfortunately, however, many large irrigation, industrial, and public water supplies obtained from wells are operated year after year without such essential records being kept. Without such records the gradual depletion of the underground reservoir may escape attention until it is too late and the supply may fail. However, by measuring periodically the depth to water level in selected wells, the quantity of water stored in the underground reservoirs may be gaged in much the same manner as a surface-water reservoir is gaged by observing the water level.

A systematic observation-well program is an essential part of our work. During 1946, water-level measurements were made periodically in 480 wells situated in 47 counties in Kansas. In most of these wells the water level is measured weekly or monthly, but in a few it is measured quarterly. Nine wells are equipped with automatic water-stage recorders. Some of the wells are in places where only small quantities of water are pumped for domestic or stock use while some are in places where large quantities of water are pumped for industrial, municipal, or irrigation use. The records are published in the annual water-level reports of the Federal Geological Survey.

The water-level measurements are generally made by the wetted-tape method which consists of letting a steel tape down into the well from a fixed measuring point at the top until a short length at the lower end of the tape is submerged in the water. A reading is then made at the measuring point, the tape is pulled up, and a reading is made at the water mark on the tape. The submerged part of the tape is generally covered with a film of blue carpenter's chalk which makes the water mark more visible. The depth to the water level is obtained by subtracting the submerged part of the tape from the reading at the measuring point.

The Geological Surveys and the related state agencies are eager to cooperate with water works men and well drillers in obtaining good and continuing records of this kind. Many invaluable records are lost each year because many water works officials fail to recognize the importance of keeping logs of test holes and wells and records of water levels and pumpage data. One of the objectives of our cooperative ground-water program is to collect as many logs of test holes and wells and the records of as many wells as possible so that these data will be available to consulting engineers or geologists,

drilling contractors or others when called in by the water departments to revise or expand their water-supply system. Large ground-water supplies such as are required for industrial, municipal, and irrigation use can be developed on a sound basis in any area only if adequate information regarding the ground-water resources of that area is available. The principal objective of our cooperative ground-water program in Kansas is to make a complete study of the ground-water resources of the state so to be able to furnish this information when needed.

Selected References

ABERNATHY, G. E., 1941, Ground-water resources of Mississippian and older rocks in Bourbon, Crawford, Cherokee, and Labette Counties, Southeastern Kansas: Kansas Geol. Survey Bull. 38, Part 8, pp. 221-236, fig. 1.

———, 1943, Deep water well at the Jayhawk Ordnance Works in Cherokee County, Kansas: Kansas Geol. Survey Bull. 47, Part 3, pp. 77-112, figs. 1-4.

BYRNE, F. E., and McLAUGHLIN, T. G., 1947, Geology and ground-water resources of Seward County, Kansas; Kansas Geol. Survey Bull. 69, in press.

FISHEL, V. C., 1947, Ground-water resources of the Kansas City, Kansas area: Kansas Geol. Survey Bull. 71, in press.

———, and LOHMAN, S. W., 1947, Geology and ground-water resources of Republic County and northern Cloud County, Kansas: Kansas Geol. Survey Bull. 73, in press.

FRYE, JOHN C., 1940, A preliminary report on the water supply of the Meade Artesian Basin, Meade County, Kansas: Kansas Geol. Survey Bull. 35, pp. 1-39, figs. 1-7, pls. 1-5.

———, 1941, Reconnaissance of ground-water resources of Atchison County, Kansas: Kansas Geol. Survey Bull. 38, Part 9, pp. 237-260, pls. 1-3, figs. 1-6.

———, 1942, Geology and ground-water resources of Meade County, Kansas: Kansas Geol. Survey Bull. 45, pp. 1-152, pls. 1-12, figs. 1-13.

———, 1945, Geology and ground water resources of Thomas County, Kansas: Kansas Geol. Survey Bull. 59, pp. 1-111, pls. 1-6, figs. 1-13.

———, and BRAZIL, JAMES J., 1943, Ground water in the oil-field areas of Ellis and Russell Counties, Kansas: Kansas Geol. Survey Bull. 50, pp. 1-104, pls. 1-2, figs. 1-9.

LATTA, B. F., 1941, Geology and ground-water resources of Stanton County, Kansas: Kansas Geol. Survey Bull. 37, pp. 1-119, figs. 1-6, pls. 1-9.

———, 1944, Geology and ground-water resources of Finney and Gray Counties, Kansas: Kansas Geol. Survey Bull. 55, pp. 1-272, figs. 1-21, pls. 1-12.

———, 1947, Geology and ground-water resources of Kiowa County, Kansas: Kansas Geol. Survey Bull. 65, in press.

LOHMAN, S. W., 1941, Ground-water conditions in the vicinity of Lawrence, Kansas: Kansas Geol. Survey Bull. 38, Part 2, pp. 17-64, pls. 1, 2.

———, 1942, Ground-water supplies available for national defense industries in south-central Kansas: Kansas Geol. Survey Bull. 41, Part 1, pp. 1-20, figs. 1-5.

———, and others, 1942, Ground-water supplies in Kansas available for national defense industries: Kansas Geol. Survey Bull. 41, Part 2, pp. 21-68, pls. 1-4, figs. 1-3.

———, and FRYE, JOHN C., 1940, Geology and ground-water resources of the "Equus beds" area in south-central Kansas: Economic Geology, vol. 35, No. 7, pp. 839-886, figs. 1-5.

McLaughlin, T. G., 1942, Geology and ground-water resources of Morton County, Kansas: Kansas Geol. Survey Bull. 40, pp. 1-126, figs. 1-6, pls. 1-9.

———, 1943, Geology and ground-water resources of Hamilton and Kearny Counties, Kansas: Kansas Geol. Survey Bull. 49, pp. 1-220, figs. 1-18, pls. 1-17.

———, 1946, Geology and ground-water resources of Grant, Haskell, and Stevens Counties, Kansas: Kansas Geol. Survey Bull. 61, pp. 1-221, pls. 1-12, figs. 1-18.

Meinzer, O. E., 1923, The occurrence of ground water in the United States, with a discussion of principles: U. S. Geol. Survey Water-Supply Paper 489, pp. 1-321, figs. 1-110, pls. 1-31, maps.

———, 1923a, Outline of ground-water hydrology, with definitions: U. S. Geol. Survey Water-Supply Paper 494, pp. 1-71, figs. 1-35.

———, and Wenzel, L. K., 1942, Movement of ground water and its relation to head, permeability, and storage: Hydrology, pp. 444-477, McGraw-Hill Book Co., New York.

Moore, R. C., 1940, Ground water resources of Kansas: Kansas Geol. Survey Bull. 27, pp. 1-112, figs. 1-28, pls. 1-34.

Waite, H. A., 1942, Geology and ground-water resources of Ford County, Kansas: Kansas Geol. Survey Bull. 43, pp. 1-250, figs. 1-22, pls. 1-16.

———, 1947, Geology and ground-water resources of Scott County, Kansas: Kansas Geol. Survey Bull. 66.

Williams, C. C., 1944, Ground-water conditions in the Neosho River Valley in the vicinity of Parsons, Kansas: Kansas Geol. Survey Bull. 52, Part 2, pp. 29-80, figs. 1-9, pls. 1-3.

———, 1946, Ground-water conditions in Elm Creek Valley, Barber County, Kansas: Kansas Geol. Survey Bull. 64, Part 3, pp. 77-124, pls. 1, 2, figs. 1-9.

———, 1946, Ground-water conditions in Arkansas River Valley in the vicinity of Hutchinson, Kansas: Kansas Geol. Survey Bull. 64, Part 5, pp. 145-216, pls. 1-6, figs. 1-11.

Reclamation in the Kansas Basin

WILLIAM C. BRADY
U. S. Dept. of the Interior, Bureau of Reclamation, Topeka.

Interest in flood control and irrigation in Kansas has been re-aroused in recent months following disastrous floods in the Missouri River Drainage Basin. The last Congress, in its closing days, made special appropriation for the construction of the Cedar Bluff Reservoir on the Smoky Hill River in Trego and Ellis Counties.

At the request of the editor, Mr. William C. Brady, Area Planning Engineer for the U. S. Bureau of Reclamation, has kindly prepared the following account describing the present status of reclamation projects on the Kansas River and its tributaries. Mr. Brady also summarizes future work contemplated in the Kansas Basin by the Federal Government.—The Editor.

The Kansas River is formed by the junction of the Smoky Hill and Republican Rivers near Junction City, Kansas. The entire area drained by these two rivers as well as that along the main stem of the Kansas River above its junction with the Missouri River at Kansas City is known as the Kansas River Basin. The areas drained by these two principal tributaries of the Kansas River are the Smoky Hill Sub-basin and the Republican Sub-basin. In these two sub-basins, lying principally in Kansas but extending into Nebraska and Colorado, the Corps of Engineers, War Department, and the U. S. Department of Interior acting principally through the Bureau of Reclamation, are planning the development of the water resources of the area. Status of planning ranges from preliminary investigations to detailed plans and specifications. In some instances construction has started on a number of multiple purpose projects designed to provide for irrigation, flood control, stream pollution abatement, fish and wildlife benefits, recreational facilities, and silt storage. All of these contemplated developments are a part of the Missouri Basin Project as conceived by Brigadier General Lewis E. Pick of the Corps of Engineers, U. S. Army, and W. G. Sloan of the Bureau of Reclamation. This plan of development, known as the Pick-Sloan plan was approved and partly authorized by the Flood Control Act of December 22, 1944.

In the Smoky Hill Sub-basin there are six units of the Missouri Basin Project as listed in the following tabulation:

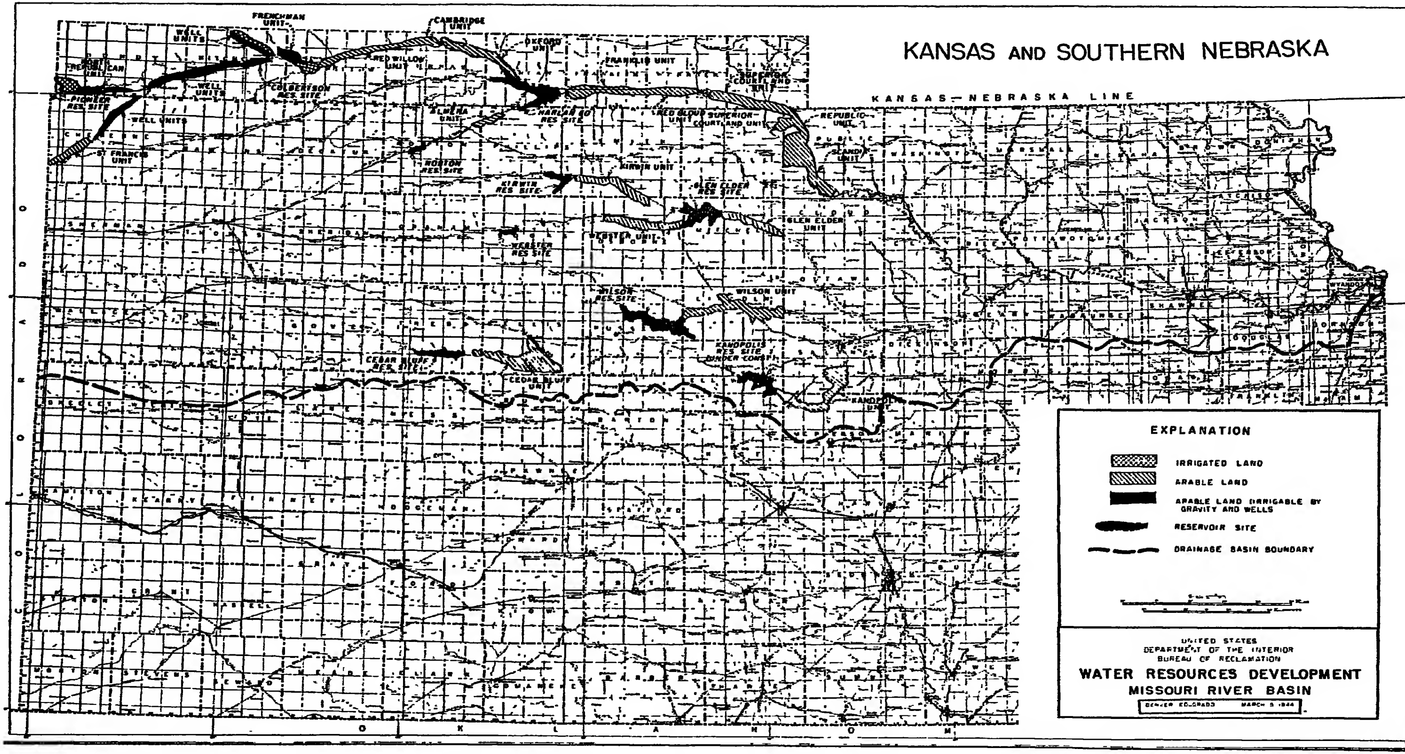
SMOKY HILL SUB-BASIN
UNITS OF MISSOURI BASIN PROJECT

Unit	Stream	Acres to be Irrigated	Reservoir — Total storage capacity/acre-feet
Kirwin	North Fork Solomon	11,000	200,000
Cedar Bluff	Smoky Hill	6,800	352,200
Kanopolis	Smoky Hill	41,000	450,000
Wilson	Saline	23,000	388,900
Webster	South Fork Solomon	9,000	224,000
Glen Elder	Solomon	26,000	399,600

Investigations, planning, and design for two of these units have been advanced to a stage where construction can begin on short notice. These are the Kirwin Unit located in Phillips, Smith, and Osborne Counties and the Cedar Bluff Unit located in Trego and Ellis Counties. Actual construction of irrigation facilities on either of these units must await the formation of irrigation districts and the testing of state laws governing both the formation of such districts and the appropriaion of water for irrigation and other beneficial uses. However the last Congress, in the closing days of the session, passed a supplemental appropriation for the construction of certain reservoirs in the Missouri River Basin as a flood control measure. The only reservoir in Kansas included in that list was the Cedar Bluff Reservoir. As a result of this legislation, the construction of Cedar Bluff Reservoir is expected to get under way during the fiscal year ending July 1, 1948. No work can be done on the irrigation facilities for this unit until an irrigation district organization has been completed and a repayment contract negotiated between the irrigation district and the Government.

Organization of the Kirwin Irrigation District was initiated a little over a year ago; however, a small group opposed to the development have been successful in blocking the organization through court action. At the present time the District organizers are preparing to circulate a new petition for the organization of the District under the revised irrigation district law, amended in the last session of the Kansas legislature.

The largest irrigation development in the Smoky Hill Sub-basin will be the Kanopolis Unit located in Ellsworth, McPherson, and Saline Counties. At the present time the Kanopolis Dam with 450,000 acre-feet capacity for flood control is being built by the Corps of Engineers and is nearing completion. Irrigation of the Kanopolis Unit would be made possible by the reallocation of 162,500 acre-feet of the capacity of Kanopolis Reservoir to irrigation storage and the construction of replacement flood storage in Cedar Bluff Reservoir. Due to the easterly location and rather high semi-humid precipitation, the Bureau of Reclamation is being assisted by other agencies in determining the value of irrigation. The Kansas State College, Bureau of Plant Industry, and the Soil Conservation Service, together with the Bureau, have determined the feasibility of practicing irrigation in this area. Most serious handicap to the early development of this unit is a lack of information as to the possibilities of



Reclamation projects in the Kansas Basin. The heavy broken line running East and West across the map marks the boundary between the Missouri River Basin, of which the Kansas Basin is a part, and the Arkansas River Basin.

irrigation by the majority of the landowners. It has not therefore been given preference in planning work.

The Wilson Unit is located in Lincoln, Cloud, and Ottawa Counties. Local landowners are very interested in developing irrigation on this unit and as a result planning studies are to be expedited with completion scheduled during the present fiscal year.

No detailed investigations have been initiated on the Webster and Glen Elder Units, all studies and surveys having been made as a part of a general investigation of irrigation possibilities in the entire sub-basin. It is anticipated that some detailed investigation will be initiated during this fiscal year and completed in the following years as funds are appropriated for this purpose by Congress.

Another possible unit being considered in the Smoky Hill Sub-basin is located on Rose Creek in Wallace County. This project would store spring flow and a small amount of surface runoff of a small tributary of the Smoky Hill southeast of Sharon Springs. The tentative size of this development is 1,200 acres. Runoff records will have to be collected for several years before information pertaining to the water supply is known.

Irrigation development in Nebraska is several years ahead of that in Kansas and since much of the Republican Sub-basin lies in Nebraska it follows that the status of irrigation development in the Republican Sub-basin is more advanced than the development in the Smoky Hill Sub-basin. Farmers and business men alike in the Republican Sub-basin in Nebraska have had ample proof of the economic improvement which irrigation brings to an area in observing the growth of irrigation in the Platte River Valley to the north and its beneficial effect on the economic well being on all of the residents of that valley. As a result they are actively engaged in doing everything possible to speed such developments in their own area.

Total development of the Republican River in Nebraska and Kansas as presently planned would provide for the irrigation of about 1,188,000 acres of land of which about 22,000 acres will be supplied supplemental water for land now inadequately watered. Of this acreage about 77,000 acres are in Kansas. By far the largest single development contemplated for Kansas is the Bostwick Unit on the lower Republican River. This project would irrigate 63,500 acres of land in Jewell, Republic, and Cloud Counties. Surveys on this unit are being expedited and initiation of district organization is expected this fall. Water for the Bostwick Unit in both Nebraska

and Kansas will be stored in the Harlan County Reservoir. Water from this reservoir will be released into the river and diverted at various points along the river to serve the project lands. The Harlan County Dam is now under construction by the Corps of Engineers.

Progress on the Upper Republican River is even more advanced. A contract has been awarded and work started on the Enders Reservoir on Frenchman Creek. Construction will also be started this fiscal year on Medicine Creek Dam on Medicine Creek, Culbertson Dam on the Republican River, and Bonny Reservoir on the South Fork Republican River. The Bonny Reservoir will serve the St. Francis Unit in Cheyenne County, Kansas, which will ultimately irrigate some 6,500 acres. Work on the Bonny, Culbertson, and Medicine Creek Reservoirs will be initiated under the same supplemental appropriation as the Cedar Bluff Dam in Kansas, previously mentioned, and will be used solely for flood control until irrigation districts are organized and construction of the irrigation facilities is completed.

The Pick-Sloan Plan will provide for irrigation development of over 1,300,000 acres in the Kansas Basin of which over 194,000 acres will be in Kansas. This irrigated Kansas land is expected to increase the state's annual agricultural gross income by over $5,000,000 and in addition flood control benefits will aggregate over $3,000,000. The unique part of the Missouri Basin Project is that it provides a means of constructing units in Kansas and Nebraska that would not be built otherwise. This since power, irrigation, and flood benefits of the whole basin are lumped together to justify the entire plan which has a favorable ratio of annual costs to annual benefits of 1 to 2.57.

The Editor's Page

Transactions
of the
Kansas Academy of Science
Published Quarterly
by the
KANSAS ACADEMY OF SCIENCE
(Founded 1868)
OFFICERS
John C. Peterson, Manhattan, President.
F. C. Gates, Manhattan, Secretary.
S. V. Dalton, Hays, Treasurer.

Vol. 50, No. 2 September, 1947

ROBERT TAFT, *Editor*

The first report of President Truman's Scientific Research Board was made by its chairman, John R. Steelman, late in August of the current year.* The 73 page report, *Science and Public Policy: A Program for the Nation,* makes interesting reading to the scientist. The Board recommends yearly expenditure of 1% of the national annual income for scientific research by 1957, an amount that exceeds two billion dollars. Emphasis is placed on methods for adding to our store of basic—as contrasted to applied—knowledge; the basic knowledge is to be acquired by fundamental research in our colleges, universities, and private, but non-profit, institutions. The annual appropriation for such research alone is set in the Steelman report as $250,000,000. Of the funds for the over-all program, it is suggested, one-half are to be supplied by the Federal Government, the remainder to be furnished by industry, education and private organizations.

President Truman himself hails the program as one "that should greatly advance the nation's position in scientific research and development." In the light of Mr. Truman's reaction to the recommendations of his Board it is difficult to understand his veto of the bill establishing the National Research Foundation—one of the important objectives to be attained in carrying out the Steelman plan. To put his action in the kindest light, one can only say that President Truman was very poorly advised. If the intensive development of scientific research is of utmost necessity for the national welfare and defense, the action of the President has delayed by possibly several years the initiation of the greatly enlarged national research program. Many words have been written in the past two years on the need for this program. What is needed now is positive action. It is to be hoped that Congress will enact and the President approve, with as little delay as possible, suitable legislation that will give life and action to a national research policy and foundation. All Kansas senators and representatives in Congress are urged to support such action.

* * *

For the summer vacation just passed, the editor deserted his

**Science and Public Policy: A Program for the Nation,* John R. Steelman, August 27, 1947. Copies may be secured from the Supt. of Documents, U. S. Government Printing Office, Washington 25, D. C. for twenty cents.

favorite love, the wide open spaces and mountains of the West, and motored east. One is tempted to make comparisons of East and West on the basis of the trip but such comparisons would require space that might better be taken up with other matters. Extended travel, either east or west, cannot but convince one that ours is a truly great land; great not only in its virtues and attractiveness but great in faults and in squalor as well.

The feature that is of most concern to the traveler on a motor trip, however, is the character and condition of the highways. Traveling east one encounters nearly every type, from superb high speed roadways to rough and narrow roads along which progress is made only at a snail's pace. The Merritt Parkway of Connecticut was one of the most outstanding of the super highways. Four lanes, attractive landscaping and beautifully and individually designed over-passes combine to make travel on this road a real pleasure. Some of the New York parkways are not far behind the Connecticut one but the longest of the super highways was encountered in the well-known Pennsylvania Turnpike through the center of the Keystone State and the Allegheny Mountains. Here one finds 160 miles of excellent roadway and scenery unimpeded by towns, cities, or cross traffic; a small segment of the trans-continental super highway of the future. On the other hand one of the worst of the roadways encountered was also found in Pennsylvania for U. S. Highway 22 in northeastern Pennsylvania and New Jersey is a motorist's nightmare. Highly congested with passenger car and truck traffic, narrow, winding, passing through numerous towns, under construction and repair, are factors all producing hazards that make the traveler wish he were at home; and it is difficult to see how the construction now under way will produce much improvement although locally one hears comment that the Turnpike—with which U. S. 22 connects—is to be extended both east and west. Construction of highways, of course, is a major necessity brought on by the lack of building and repair during the war and extensive construction work was found along the main arterial east-west highways of U. S. 20, 30, and 40. Much of the construction on these roads is devoted to the conversion of 2 lane highways into the much needed 4 lane systems.

One other feature of highway travel, the roadside parks, deserves brief comment. Many were encountered on the thirty-five hundred mile trip and they always produced the pleasant impression of hospitality as well as affording a relief from the ordinary beside-the-road sights. These roadside parks were especially well developed and numerous through Ohio and Indiana and their example could well be followed by Kansas. The editor recalls a few such parks in his travels around the state but a far greater number could be provided in the ample space along many Kansas roads.

* * *

Mr. V. C. Fishel, the author of the feature article in this issue

of the *Transactions* is a native of Illinois. His high school training was received at Fairfield, Ill., and he was graduated from Southern Illinois Normal University at Carbondale in 1930 with a major in physics. A year prior to his graduation, however, he had entered service with the United States Geological Survey in Washington. His professional

V. C. FISHEL

training as a geologist was received at George Washington University. Mr. Fishel continued his work at Washington headquarters of the U.S.G.S. from 1929 until 1941, where he was in charge of the hydrologic laboratory. In 1941 he was assigned to the Kansas Ground-Water Division, a cooperative effort between U.S.G.S. and the State Geological Survey, as engineer in the Kansas water program. The Division, originally established in 1937, now consists, in addition to the executive officer, of five geologists, an instrument man, a scientific aide, a draftsman, and two office employees, and occupies a suite of offices and laboratories in Lindley Hall, University of Kansas. Much of the work of the Division, it scarcely need be said, is carried on in the field. Included in the equipment for field work possessed by the Division, is a test drilling rig, requiring three operators for its use and capable of penetrating 800 foot depths. Much of the test drilling done, however, does not exceed 200 feet in depth. During the summer of 1947, the drilling rig has been used extensively in southeastern Kansas.

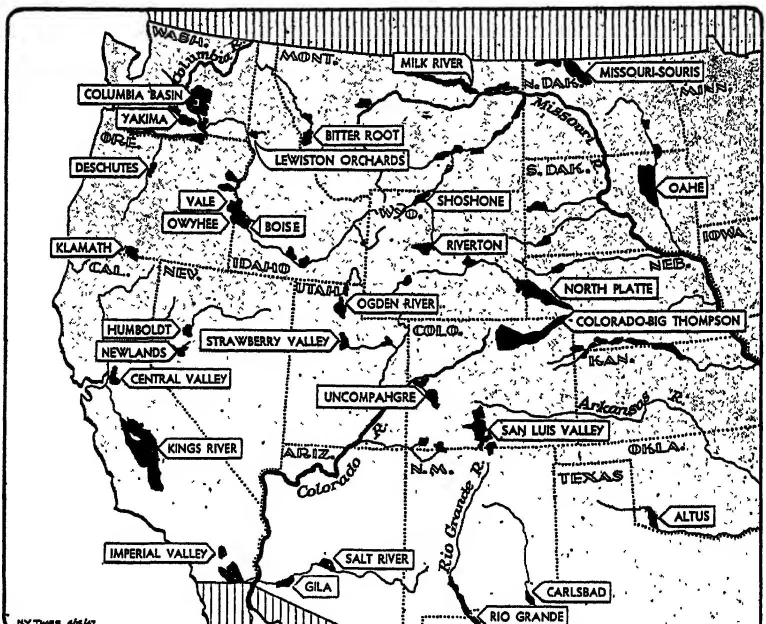
* * *

Readers of the *Transactions* will be indebted to William C. Brady of the Bureau of Reclamation for his account of flood control and irrigation projects in the Kansas Basin published on page 115. The Kanopolis Dam mentioned by Mr. Brady, the largest undertaking of its kind in Kansas, is according to report of September 13, some 70 per cent complete. If favorable weather exists for the remainder of the year, construction will be complete by January 1, 1948. The ten million dollar dam now has an average height of 100 feet and when completed will rise to 130 feet. The service road which will cross the dam will be three miles long! Four hundred men in two ten-hour shifts are working on the dam, moving earth at the rate of 17,000 cubic yards daily.

Progress is also being made in clearing the upstream reservoir area of buildings, trees, stumps and debris. Clearing is reported as 35 per cent complete at present.

Reclamation in the remainder of the West is far more extensive than in Kansas as can be clearly seen in the map below. ever, occurs in the Columbia Basin. This project with an estimated cost of $355,000,000 will impound water behind the Grand Coulee Dam and lead it through 100 miles of tunnels and canals to irrigate 1,000,000 acres of previously unused land in Oregon. "The Reclamation Service," reports a recent issue of the New

THE WEST'S GREAT RECLAMATION AREAS



—Reproduced by courtesy of the New York Times.

Notable among the great Federal reclamation projects are the 13-mile Colorado-Big Thompson project designed to bring irrigation to 615,000 acres of sugar beet fields on the plains bordering the eastern edge of the Rockies. The largest single irrigation development of all, how- York *Times,* "builds the dams that irrigate the farms and property for millions of Americans living between the Great Plains and the Pacific Coast. In forty-five years it has become as indispensable a part of Western life as the postal system and the technicolor landscape."

Scientific News and Notes of Academy Interest

Items for this column are solicited from all Academy members. For inclusion in any given issue they should be in the editor's hands at least three weeks before our publication dates, namely the fifteenth of March, June, September and December.

Professor Roy Rankin, for the past 29 years head of the department of chemistry at Fort Hays Kansas State College, retires this year from his administrative duties but will continue as a full-time teaching member of the department. Dr. Harold S. Choguill, formerly associate professor of chemistry, has been promoted to a full professorship and becomes head of the department.

Dr. John Breukelman, professor of biology of Kansas State College, Emporia, spent the latter part of the summer investigating fish life and conditions for the State Fish and Game Commission.

A new department of geography has been organized at the University of Kansas, Lawrence. The new department whose offerings were formerly taught as part of the curriculum of geology, will be headed by Professor Walter Kollmorgen. Dr. Thomas R. Smith, has been added as associate professor of geography, and Dr. Walter Schoewe will divide his time between the departments of geology, geography, and the State Geological Survey.

Professor Lawrence Oncley, since 1918 chairman of the chemistry department of Southwestern College, Winfield, retired at the end of the past school year. Professor Oncley, however, is not content to rest on his emeritus status, but, beginning October first, will become chemist for the H. L. Snyder Memorial Research Foundation of Winfield. The Snyder Foundation, established some two years ago for the investigation of medical and biochemical problems, is an outgrowth of the Snyder and Jones Medical Clinic and for the past two years has been under the direction of Miss Letha Bunch, formerly instructor in biochemistry at the University of Kansas. A new laboratory building is under construction for the use of the Snyder Foundation and will be ready for occupancy this fall.

Professor Oncley will be succeeded by Dr. Leroy A. Spitze, a graduate of Southwestern College in 1939 who received his doctorate from Rensselaer Polytechnic Institute in 1942. Mr. Etcyl Blair, A.B., Southwestern College, 1947, will also serve as instructor in chemistry beginning with the fall semester.

Dr. Paul A. Dahm of the University of Illinois and Dr. Louis C. Kintert of the University of Kansas become assistant professors of entomology at Kansas State College, Manhattan, beginning September first.

Rex W. Woods has been named professor of petroleum engineering and departmental chairman at the University of Kansas, Lawrence. Professor Woods, a graduate of Pennsylvania State College, has been employed since 1936 by the Gulf Oil Corporation and the Creole Petroleum Corporation, Caracas, Venezuela. Prior to his commercial experience, Professor Woods was in charge of petroleum and natural gas extension work at Pennsylvania State College.

Dr. H. T. Gier, a graduate of Kansas State Teachers College, Pittsburg, and the University of Indiana, and Dr. Otto W. Tiemeier, a graduate of the University of Kansas and the University of Illinois, have been added to the staff of the zoology department of Kansas State College, Manhattan. Dr. Gier will serve as associate professor and Dr. Tiemeier as instructor in zoology.

T. DeWitt Carr, captain, U.S.N., retired, and a graduate of Annapolis in 1916, became dean of the school of engineering and architecture, University of Kansas, on September first. Dean Carr succeeds Professor J. O. Jones, who has been acting dean since 1943.

Dr. R. H. Painter, professor of entomology, Kansas State College, Manhattan, spent his vacation month of August in study at the European Corn Borer Laboratory, Toledo, Ohio. Mr. Leonard M. Redlinger also of the department of entomology, Manhattan, spent the summer in Alaska on a mosquito survey conducted by the U. S. Bureau of Entomology and Plant Quarantine.

Messrs. Bruce F. Latta and O. S. Fent have resigned their positions with the U. S. Geological Survey, Lawrence, to establish the firm of Latta and Fent, ground-water geologists at Salina. The firm will make water supply surveys and explorations for municipal, industrial, railroad and irrigation uses.

After a lapse of five years the Yearbook series begun about fifty years ago by the United States Department of Agriculture has been resumed. The latest issue, entitled *Science in Farming,* covers the period 1943-47. Published as a House Document of the 79th Congress, the new yearbook may be obtained from the Superintendent of Documents, Washington 25, D. C., at $2.00 a copy. It contains 135 essays written by members of the research staff of the Department and covering 944 pages. Of these essays, two are about the Department's research backgrounds, 23 relate to animals, 32 to field and garden crops, five to trees, 16 to soils, 15 to insects, nine to new farm products, nine to food and clothing, 22 to new agricultural practices, and two state the "conclusion of the whole matter." There is an abundance of good illustrations. Although the essays were written primarily for the layman, they are, nevertheless, valuable, as well as interesting, to the scientist.—F.D.F.

Dr. Cecil G. Lalicker has been appointed professor of geology at the University of Kansas. Dr. Lalicker comes to the University from the Colorado School of Mines and is a graduate of the University of Oklahoma and of Harvard University.

Professor William H. Honstead has been appointed acting head of the department of chemical engineering, Kansas State College, Manhattan, following the resignation of Professor F. A. Rohrman who became director of the experiment station at the University of Colorado. Other changes in the department of chemical engineering at Manhattan include the appointment of Dean E. Braden as assistant professor and of Donat B. Bryce as instructor.

A total grant of $84,000 for five projects was made during the summer by the Kansas Industrial Development Commission for the year ending July 1, 1948. At Kansas State College, Manhattan, the Commission subsidizes projects for the studies of the derivation of starches from sorghums, for the dehydration of foods, and for the nutritive value of wheat. At the University of Kansas, the Commission will continue projects pertaining to the chemical utilization of natural gas and for the production of plastics from raw materials found in the state.

During the past summer, both deer and antelope have been reported in Russell County. These reports, if confirmed, are of interest as both mammals have been previously reported as extinct in the state.

Dr. and Mrs. L. J. Gier of William Jewell College, Liberty, Mo., spent the latter part of August making an extensive collection of mosses over the state of Missouri.

The Stanolind Oil and Gas Company, Tulsa, Oklahoma, has established a fellowship paying $1250.00 for the investigation of solutions of certain salts of sulfonic acids at the University of Kansas, department of chemistry. Mr. John A. Poje, formerly a graduate instructor in the department, has been appointed to fill the fellowship. The Stanolind Fellowship is the eighteenth fellowship to be established in the department of chemistry within the past two years.

Dr. Robert W. Wilson of the University of Colorado, and Mr. Carlyle S. Smith of Columbia University, have been appointed assistant curators in the Museum of Natural History, University of Kansas. Dr. Wilson will also serve as assistant professor of vertebrate paleontology and Mr. Smith as assistant professor of archeology and anthropology.

Dr. Mary T. Harman, for 35 years a member of the zoology staff of Kansas State College, Manhattan, and Dr. H. W. Brubaker, for 34 years a member of the chemistry staff at Kansas State, retired on July 1. Both will continue as half-time members of the staff and Dr. Harman, of course, will continue her duties as associate editor of these *Transactions.*

It is with deep regret that we announce the death of two members of the Academy during the summer just past. Mr. Ira D. Graham, who joined the Academy in 1879 and was before his death the oldest in point of membership in the Academy, died in Topeka on July 14, 1947. Mr. Graham for over half a century a staff writer for the State Department of Agriculture, was widely known as one of the most ardent and enthusiastic supporters of Kansas agriculture.

The death of Professor Leo H. Hudiberg, professor of physics and assistant dean of the school of arts and sciences, Kansas State College, occurred July 23, 1947, at Manhattan. Professor Hudiberg, "one of the best-liked and most conscientious instructors" of the Kansas State staff, had served the College for 17 years. His untimely death at the age of 49 will be regretted by all members of the Academy.

President Rees H. Hughes, Kansas State Teachers College, Pittsburg, was a delegate to the seminar on education held by the U.N.E.S.C.O. at Paris. The seminar was held from July 21 to August 30. President Hughes was one of six American educators who were delegates to the seminar.

Published by the University of Oklahoma Press in 1947 and selling at retail for $3.50 a copy, *Two Blades of Grass* by T. W. Harding is an interesting and informative account of the history and the achievements of the United States Department of Agriculture. Beginning with the rudimentary origin of the Department as a small section of the Patent Office a hundred years ago, the author traces the development of the Department to the year 1946. The story is written around the personalities, the achievements and the devotion of the scientists who have made the U.S.D.A. one of the largest and most effective scientific research organizations in the world. In an easy, chatty style the author relates the tribulations, the triumphs and the occasional failures of these scientists. Anybody interested in scientific research as an instrument of progress may read the book with pleasure and profit.—F.D.F.

Dr. R. Stanley Alexander has been promoted to the rank of associate professor and made acting head of the department of physics and astronomy at Washburn Municipal University, Topeka. Dr. Alexander succeeds Dr. Philip S. Riggs who resigned to accept a position at Drake University, Des Moines. Also at Washburn, Dr. Donald H. Webb has been appointed assistant professor of physics and aeronautics.

During the summer Miss Laura Lee Tolsted and Mr. Howard O'Connor were added to the staff of the State Geological Survey, Lawrence, as assisting geologists. Mrs. Marjorie Utter was also appointed chemist on the Survey staff.

Three mastodon teeth, additional evidence of mastodons in Kansas, were received by the

museum of Kansas State College during the summer. The ancient molars were discovered in a sand pit near Junction City on the Republican River by William Darnell.

Dr. Dexter B. Sharp, a graduate of the University of Nebraska, and Dr. John De Vries of the University of Illinois, have been added to the chemistry department staff at Kansas State College, Manhattan.

Dr. Roger G. Barker, formerly of Clark University, is now the chairman of the department of psychology, University of Kansas. Other additions to the psychology staff at the University include Dr. Herbert F. Wright, associate professor, and Miss Margaret M. Riggs and Miss Harriette Galantiere, instructors.

Dr. John Frazier, past secretary of the Academy, has been promoted to a professorship in the department of botany and plant pathology, Kansas State College, Manhattan.

During the summer just passed the State Geological Survey was crowded with the first full line-up of field projects since the war. Twenty-seven staff members plus 10 men engaged in cooperative studies with the United States Survey worked in one or more of the Survey's six divisions—areal geology and stratigraphy, oil and gas, coal, industrial minerals and chemistry, ground-water, and topographic mapping.

A geologic mapping project, eventually to include all counties of the Flint Hills belt, was started and essentially completed in Chase and Lyon Counties by Dr. R. C. Moore, Dr. J. M. Jewett, and Howard O'Connor. Completed maps will show in one inch to the mile the geology, mineral deposits, and ground-water resources of each county.

Oil and gas investigations were confined largely to laboratory studies of well cuttings and logs by Wallace Lee, and to the collection and filing of samples, logs, and production statistics.

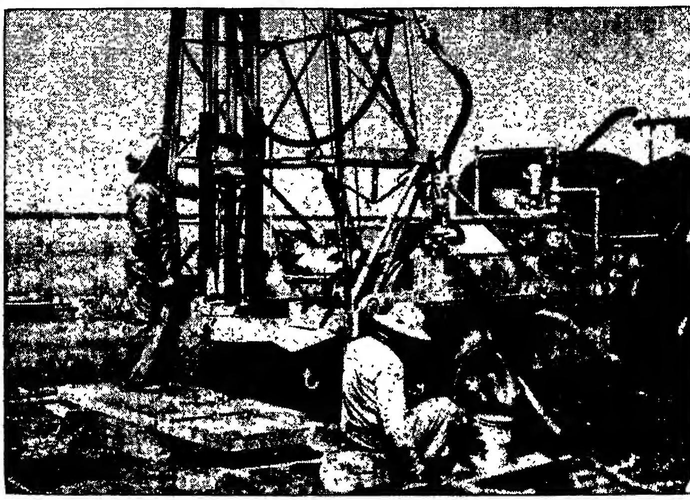
Dr. Walter H. Schoewe made a detailed study of the lignite coal deposits in Cloud, Jewell and adjacent north-central Kansas counties, and Dr. G. E. Abernathy was busy with coal investigations in southeastern Kansas.

In industrial minerals, Norman Plummer continued clay studies in more than a dozen counties, and Russell Runnels completed field work for a chemical study of Kansas chalk deposits. The petrographic character of volcanic ash and concrete aggregate rock of central and western Kansas were examined by Ada Swineford, and a process for manufacture of artificial light and heavy aggregate was developed in the ceramics laboratories. Earl K. Nixon began a survey of the state's mineral industries — gathering mineral statistics that will aid in the further development of mineral deposits, and Dr. R. M. Dreyer supervised magnotometer and radioactivity surveys of structures in the southeastern zinc and lead area.

Under the supervision of V. C. Fishel, the cooperative State and Federal ground-water divi-

sion made investigations of underground water resources in the North Solomon River, Pawnee River, and Prairie Dog Creek valleys, and in Norton, Greeley, Wichita, Jewell, Rice, Edwards, and Pawnee Counties. Test drilling by hydraulic rotary machine, operated by the division, was done or will be done for each of these areas.

Cooperative State and Federal topographic mapping projects got under way in Bourbon, Crawford, and Neosho Counties and along the Kansas River valley between Topeka and Kansas City.



Portable hydraulic test drill operated by the cooperative State and Federal Surveys' ground-water division to secure accurate data on underground water resources.

Basic research traditionally has been conducted in the colleges and universities. While industry engages in some basic research and the Government laboratories conduct a somewhat greater amount, the proportions in both instances are small. The principal function of the colleges and universities is to promote the progress of learning and they must be the primary means through which any expanded program of basic research is carried out.

The support of basic research is the most important single element in the entire National Science Program. In the final analysis, all else depends upon the extension of fundamental knowledge which is its object, and upon the training of young scientists which is its by-product.—John R. Steelman, *Science and Public Policy,* 1947.

Survey of the Fossil Vertebrates of Kansas: Part V: Mammalia

H. H. LANE
University of Kansas, Lawrence

Introduction

The Class Mammalia marks the culmination of vertebrate development. When they first appeared in the Upper Triassic of South Africa—possibly in South China as well—the mammals were a group of small or very small creatures difficult to distinguish from their progenitors, *viz.*, certain Therapsidan reptiles.* Throughout the remainder of the Mesozoic Era, the mammals were overshadowed by the hosts of reptiles, including the dinosaurs and numerous other forms, in competition with which it would seem they must have led a precarious existence.

When compared with the classes of lower vertebrates previously discussed in this survey, the mammals display a number of distinguishing characteristics. Thus in all of them the body is more or less completely covered with *hair,* though this is greatly reduced in man and in such aquatic forms as the whales and their kin, which though hairy when young lose all but a few bristles about the mouth. *Oil glands,* except in the aquatic forms, are numerously distributed over the body which keeps the hair and skin pliable; *sweat glands* are generally present as part of the temperature-controlling apparatus; and *milk glands* furnish nourishment for the young. It is from the presence of these milk glands, technically called *mammary glands* since they are typically aggregated in the *mammae,* or "breasts", that this class takes its name, *Mammalia.* The milk glands are present in both sexes, though usually vestigial in the males while functional in the females.

With the exception of the egg-laying monotremes, the young of mammals are born alive (*viviparity*). In the case of the monotremes, confined to Australia and a few neighboring islands, the eggs are fairly large, yolk-laden, and covered with a leathery shell such as occurs in most lizards and many snakes. In all other mammals the eggs are microscopic in size, have very little yolk, and no shell. They undergo their development within a special organ (*uterus* or "womb") inside the body of the mother, with which, except in the marsupials generally, the fetus is connected by a pecu-

Transactions Kansas Academy of Science, Vol. 50, No. 2, 1947.

*See *Part II: The Reptiles,* of this survey, in the Transactions of this Academy, Dec., 1946, No. 3, pp. 293 and 299.

liar structure termed the *placenta,* through which nourishment is passed from the mother to the young, and the waste-products of the latter are gotten rid of. In the development of the mammalian placenta there are involved three embryonic membranes (*chorion, amnion,* and *allantois*), all of which are found also in the reptiles and birds.

In the marsupials, *e.g.*, the opossum, the young are born in a very immature condition and make their way at once into a pouch (*marsupium*) or pocket on the ventral side of the mother's body, wherein they become attached to the nipples and remain until mature enough to take care of themselves. They do not actually nurse in the earlier part of post-natal life, but instead the mother *pumps* the milk down their throats. They have an adaptive development of the epiglottis which prevents the milk from entering the wind-pipe and thus strangling them.

In the placental mammals, on the other hand, the young are born in a much more mature condition, and in many cases are able, after a very few hours, to run about at a speed about equal to that of the mother. A familiar example of this sort is found in the case of the young colt with its very long legs, which can soon follow the mare at her own speed.

In the mammals the body-cavity (*coelom*) is divided by a muscular partition (*diaphragm*) into an anterior *thoracic* and a posterior *abdominal* portion. In the thoracic cavity are located the lungs and the four-chambered heart, from which there is given off a *single* (*left*) aortic arch. The reptiles have a pair of aortic arches and the birds but one, which in this case is on the *right* side. The red-blood corpuscles in all placental mammals, except the camels, are circular in outline and are without nuclei. The non-nucleated corpuscles of the camel are oval in outline. With the assistance of the sweat glands and the liver, the vaso-motor system functions as a heat-regulating mechanism keeping the body-temperature at a constant level, varying in different species from 74° to 104° F.

In most mammals there are two sets of teeth in sockets in the jaws. The first set, called the *deciduous* or *milk teeth,* is replaced by the *permanent* set, made up typically of four kinds, *viz.,* the cropping *incisors* in front, followed by the piercing *canines,* next the *premolars* (called *bicuspids* in man), and finally the *molars,* the last not being represented in the milk set. The typical number of teeth in the permanent set is 44, though this number is often reduced, and occasionally increased.

The skull of mammals articulates with the vertebral column by means of *two* occipital condyles, and consists of fewer bones than are found in the skull of reptiles or other lower vertebrates. This reduction in number has been attained partly through loss and partly through the fusion of elements occurring in lower forms. Particularly noteworthy is the reduction of the lower jaw (*mandible*) to a single element (the *dentary*), articulating with the *squamosal* bone of the skull. The bones of the middle ear are three in number—the *stapes,* corresponding to the *columella* (in part at least) of the reptiles; the *incus,* which is the reduced and modified *quadrate;* and the *malleus,* which is the old *articulare* of the reptilian jaw.

The two-headed ribs articulate dorsally with the *centra* of the vertebrae, and ventrally with the breast-bone (*sternum*), thus providing for the expansion and contraction of the thoracic cavity in respiration. The shoulder girdle consists of only two bones at most, except in the monotremes where the *coracoid* and *precoracoid* persist as separate elements; in all other mammals the shoulder elements are the *scapula* or shoulder blade, and the *clavicle* or collar bone. However, in many mammals the clavicle is vestigial or absent. Four types of foot posture are found in mammals: (1) *plantigrade,* wherein the whole sole of the foot rests on the ground in walking, as seen in man, bears, and some other forms; (2) *digitigrade,* wherein the weight of the body is borne on the *toes* in walking or running, as in the dog or cat; (3) *unguligrade,* wherein the animal is supported on the *toe-nails,* or *hoofs,* as in the horse or cow; and (4) *graviportal,* wherein the weight is borne on a heavy pad behind the toes, as in the elephant, rhinoceros and other very large mammals.

Very conspicuous as a distinguishing trait of the mammals is the relatively large development of the brain—less so in the earlier more primitive, than in the later more highly specialized forms. This enlargement of the brain concerns more especially the *cerebral hemispheres,* which may become greatly convoluted, particularly in the whales, the elephants, many ungulates, and the Primates, where it reaches its climax in man. The *corpus callosum,* a bridge of fibres connecting the two hemispheres, is also greatly increased in size, and there is a complex, highly developed *cerebellum.* The organs of special sense, such as the eyes, the olfactory apparatus, and the ears, vary much in effectiveness—some mammals depending more upon sight or sound than upon smell for the detection of food, mates, or enemies. In other cases the reverse is true.

The Class Mammalia comprises about thirty orders, some of

which are totally extinct, the remainder with living representatives. Only ten orders have living or fossil species known from Kansas. These are:

1. *Order Marsupialia,* opossums and their kin.
2. *Order Insectivora,* moles and shrews.
3. *Order Chiroptera,* bats.
4. *Order Xenarthra,* armadillos, sloths, *et. al.*
5. *Order Proboscidea,* elephants and mastodons.
6. *Order Rodentia,* squirrels, rats, mice, *et. al.*
7. *Order Lagomorpha,* rabbits, pikas and hares.
8. *Order Carnivora,* dogs, cats, bears, *et. al.*
9. *Order Artiodactyla,* cattle, deer, hogs, *et. al.*
10. *Order Perissodactyla,* horses, rhinoceroses, *et. al.*

While there are four subclasses of mammals recognized, only the fourth, *Subclass Theria,* is represented in Kansas. The *Theria* are subdivided into two quite distinct *infraclasses,* known as the *Metatheria* and the *Eutheria* (or *Placentalia*), respectively. To the *Metatheria* belongs only the *Order Marsupialia,* while all the others fall under the *Eutheria.*

Principal Deposits in Kansas Known to Contain Mammalian Fossils

UPPER PLEISTOCENE
 Upper Kingsdown Formation
  Pyle Ranch *in part,* (Stevens Ranch), Clark County
  Jones Fauna, Meade County
 Lower Kingsdown Formation
  XI Ranch, Meade County
  Rezabek Fauna, Lincoln County
 Meade Formation
  Borchers Fauna (Interglacial), Meade County
  Pearlette Ash
  Pyle Ranch *in part,* Clark County
  Cudahy Faunule, Russell County
  Sunbrite Faunule, Meade County } all equivalent
  Tobin Faunule, Russell County
  Wilson Valley Faunule, Lincoln County
  Basal Meade Gravels
BLANCAN (Low Pleistocene and/or High Pliocene, Provisional Time Zone)
 Rexroad Formation
  Rexroad Fauna, Meade County
  Big Springs Ranch, Meade County } all equivalent
  Fox Canyon, Meade County
UPPER PLIOCENE
  Saw Rock Canyon, Seward County
  Emma Creek (*upper part;* lower part may be Ogallala)
MIDDLE PLIOCENE
 Ogallala Formation
  Edson Beds, Sherman and Wallace Counties
LOWER PLIOCENE (and possibly Upper Miocene in part)
  Long Island, Phillips County

The members of the *Subclass Theria* all bring forth their young alive (*viviparity*), in contrast to the Australian egg-laying monotremes, which are the most primitive living mammals. A cloaca is

lacking so that there is a separation of the alimentary orifice (*anus*) from those of the genito-urinary system. Of the two infraclasses of the Theria, the *Metatheria,* including only the *Order Marsupialia,* give birth to the young in a very immature condition, the remainder of fetal life being passed in a pouch (*marsupium*) on the belly of the mother. Usually no allantoic placenta is formed in connection with the development of the fetus before birth. The members of the second infraclass, the *Eutheria,* on the contrary, retain the fetus until it is well developed and invariably its needs are served before birth by means of a peculiar organ, the *placenta,* formed partly of maternal and partly of fetal tissues.

The *Order Marsupialia* is represented today in North America by opossums only, of which there is but one species living in the United States. Besides opossums, other types live in South America (the *Coenolestids*), while in Australia and its neighboring islands, this order displays numerous adaptive forms paralleling in a remarkable manner the diversity of the placentals. In some respects, notably in the architecture of the brain and in the presence of epipubic bones, the marsupials resemble the monotremes, while in the structure of the bones of the middle ear and of the shoulder girdle, as well as in the presence of nipples on the mammary glands, which latter are of the sebaceous type, they agree with the placentals. In their urinogenital organs they are intermediate between these two groups. Thus, in the marsupials, the ureters open into the base of the urinary bladder; the oviducts are differentiated into both uterine and oviductal portions, and there is a long vagina. Immediately after birth the young marsupial makes its way into the marsupial pouch of the mother and attaches itself to a nipple, to which its lips grow fast. Milk is injected into its mouth by contraction of the maternal muscles which cover the mammary gland. Strangulation of the young is prevented by an unusually long epiglottis which extends upward through the throat cavity to end in the posterior orifice of the nasal air passages, permitting the milk to flow around it without interference with respiration.

The marsupial brain is relatively small and the cerebral hemispheres are usually smooth, though somewhat convoluted in the larger species. The corpus callosum is very small, while the anterior commissure is very large. The dentition is *heterodont,* that is, the teeth are differentiated into incisors, canines, premolars and molars, but varies greatly in the number of the teeth. In almost all, the incisors are never the same in number in the upper and lower

jaws, and the true molars are usually four on each side above and below. The milk or deciduous set of teeth is conspicuous by its absence in the marsupials. There is no replacement and succession of the teeth, except in the case of the last premolar on each side above and below. This one is preceded by a more or less molariform tooth; but in some species not even a rudiment of such a tooth appears.

The number of dorso-lumbar vertebrae in the marsupials is always 19; the ribs, nearly always 13 pairs. The angle of the mandible is characteristically more or less inflected. There are two anterior venae cavae. The oviducts open separately into the vagina, which is also double for at least part of its distal portion. The mammary glands and nipples vary much in number.

Fossil marsupials have not as yet been reported from Kansas, though remains of opossums have been collected from the Upper Cretaceous (Lance formation) in both Montana and Alberta, Canada. These mesozoic marsupials are distinguished from the living opossum by only minor technical differences.

EUTHERIA

The *Infraclass Eutheria* comprises all the remaining orders of mammals. Its members are characterized by the presence of an *allantoic placenta* by means of which the fetus is nourished within the mother's *uterus* (womb) until it is born in a comparatively advanced stage of development. The brain is relatively large and better developed than in the monotremes or marsupials; the cerebral hemispheres are either smooth or convoluted and are connected by a large *corpus callosum* and smaller *anterior commissure*. The urinogenital organs have their own separate openings wholly independent of the anal orifice of the rectum. The typical number of permanent teeth in the *heterodont diphyodont* series is 44; this number is, however, exceeded in a few cases, but is reduced in a great number of species. Typically there are three incisors, one canine, four premolars and three molars on each side above and below. In only one genus of living placental mammals are there four molars in each jaw. The angle of the lower jaw is not inflected; the coracoid is reduced to a small process on the end of the scapula. The precoracoid, interclavicle, and in many cases the clavicle also are absent.

Order Insectivora:

The oldest and most primitive order of eutherian mammals is that called the *Insectivora,* which comprises among its living representatives the familiar moles and shrews. Its first known appearance

was in the Upper Cretaceous along with the first marsupials (opossums). The members of this order are found throughout North America, Europe, Asia and Africa, being entirely absent from Australia and all but the northwestern corner of South America. They are nocturnal in habit and feed upon worms and, especially, insects which they seize with the projecting front teeth and cut into pieces with the sharp-pointed cusps on their cheek teeth. The canines are usually weakly developed, and in many cases the incisors, canines and anterior premolars are not clearly differentiated from one another. The body is clothed with fine hair, or is protected by an armature of small spines, as in the Old World hedgehog. The testes are abdominal; the uterus bicornuate; the placenta discoidal and deciduate. The smooth cerebral hemispheres do not project backwards over the cerebellum. The upper jaws and snout usually extend forward far beyond the extremity of the lower jaw. A very primitive character, unique among eutherian mammals, is the presence of ossified *intercentra* in the dorso-lumbar vertebrae—a feature reminiscent of the reptiles. They are mostly *cursorial,* as the shrews, but some, like the moles, are burrowing (*fossorial*). In general, constituting a very low and generalized type of mammal, the insectivores are closely related to the ancestral forms of other later orders of placental mammals.

The Upper Cretaceous insectivores appear to have been the direct offspring of an extinct Mesozoic order, the *Pantotheria,* not represented among the fossil mammals of Kansas. The scarcity of fossil insectivores indicates that, as now, they have always been relatively few in number, yet even before the close of the Cretaceous they had evolved into at least two or three suborders. Of these suborders, the *Zalambdodonta* are known from the Upper Cretaceous of Mongolia, and the Paleocene and Eocene of North America; one family, the *Palaeoryctidae,* occurs in the Paleocene to Oligocene inclusive of North America, while another, the *Solenodontidae,* lives today in Cuba and Haiti, with two other related families in the Pleistocene to Recent of Madagascar and Africa. None of these are known from Kansas.

A second suborder, the *Dilambdodonta,* is represented in the Upper Cretaceous and Palaeocene of Mongolia; the family *Leptictidae,* of this suborder, occurs in the Upper Cretaceous to the Eocene of North America and Europe; the family *Erinaceidae* is found in the Eocene to Pliocene of North America, the Eocene to Recent of Europe and Africa, and the Pleistocene and Recent of Asia. No

member of this family, the hedgehogs, has been recorded from Kansas. The *Soricoidea* is a superfamily of the Dilambdodonta with known representatives from the Paleocene to Recent in North America; from the Eocene to Recent in Europe; and the Miocene to Recent in Asia. Two families of this group, the *Soricidae* and the *Talpidae,* the former known as shrews, and the latter as moles, have been recorded from the Middle Pliocene to Recent in Kansas, as follows:

Family Talpidae:

From the Middle Pliocene, Edson beds, Sherman County, Kansas, a form too fragmentary for specific identification, belonging to an undescribed genus of mole, was collected by Dr. David Dunkle and is now in the Museum of Comparative Zoology at Harvard University (M.C.Z., No. 6200). It is slightly larger than the living *Scalopus aquaticus machrinoides* Jackson, the Missouri Valley Mole, the type of which, now in the U. S. National Museum, Washington, D. C. (No. 169,717), came from Manhattan, Riley County, Kansas. The fossil specimen, however, differs in several respects from either the genus *Scalopus* or *Scapanus,* now living, the former in the eastern United States, the latter on our Pacific Coast.

A second fossil mole (KUMVP, No. 4928) from the Edson beds of Sherman County indicates an animal the size of the living *Scalopus aquaticus texanus* (Allen), the type of which came from Alva, Woods County, Oklahoma, not far south of the Kansas line. This fossil specimen agrees with the first in form but differs in size. Both are adult specimens and may represent the two sexes of the same undescribed genus. These are the oldest insectivores as yet found in Kansas.

The genus *Scalopus* is represented by an undetermined species of mole in the Rexroad fauna, of Meade County, and by *Scalopus aquaticus* in the Rezabek fauna, of Lincoln County. The latter species is the common Eastern Mole, living today widely distributed throughout eastern North America. It is represented by three subspecies in Kansas, namely, *Scalopus aquaticus machrinoides,* in the eastern part of this state, *S. a. intermedius* in the south central part, and *S. a. caryi* in the northwestern part.

A new genus and species, *Hesperoscalops rexroadi,* was described by Hibbard from the Rexroad fauna, of Meade County. The holotype (KUMVP, No. 4684) indicates an animal as large as *Scapanus townsendii,* of the Pacific Coast region today, which is the largest of our living moles, the males reaching a length of nine

inches. The jaw and teeth of *Hesperoscalops* are actually larger and heavier than those of *Scapanus townsendii.* Other distinguishing characteristics are too technical to be described here. Contemporaneous with *Hesperoscalops* was an indeterminate species of *Scalopus,* represented by a complete right humerus (KUMVP, No. 4624), likewise a part of the Rexroad fauna, which is very close to, if not identical with, *Scalopus aquaticus* in size, shape and structure. It differs in details from other moles from the Middle Pliocene of Kansas. *Scalopus aquaticus* itself (KUMVP, No. 6675) has been recovered in the Rezabek fauna, of Lincoln County. No doubt it or related species will be found in other Pleistocene deposits of this state when they are more carefully explored.

Family Soricidae:

Shrews are very small, somewhat mouse-like insectivores with an elongated snout, small eyes and ears, and highly specialized anterior teeth. The long narrow skull lacks the jugal arches. One genus, *Microsorex,* includes the smallest living North American mammals. The hands and feet are small, delicate, and not highly modified for digging as is the hand of a mole. The tail is relatively longer than in the moles. They are generally brownish above and lighter below; their movements are quick and nervous; mostly terrestrial, not burrowing like a mole. Total length about five inches, or, more usually, less. They are generally quite abundant, but ordinarily rarely seen because of their nocturnal habits. They are voracious feeders upon insects and earthworms, though even mice are killed and eaten when circumstances permit. Some forms are more or less aquatic and catch their food in the water.

Hibbard has recorded two genera of shrews from the Rexroad fauna, of Meade County. One he doubtfully assigns to the living genus *Blarina* (KUMVP, No. 3913), but does not identify it as to species. It appears as large as and very similar to the living *Blarina brevicauda.* Previously, the genus *Blarina* had been recorded from the Hagerman fauna, Upper Pliocene, of Idaho. The second shrew from the Rexroad fauna of Meade County, Kansas, is described as a new species by Hibbard, under the name *Sorex taylori* (holotype, KUMVP, No. 3906). The specific distinction is based upon the characters of the molar teeth. As Hibbard remarks: "The genus *Sorex* at the present time has a wide distributional range, being found throughout the major portion of Europe, Asia and North America."

The presence of this shrew in large numbers from the stream

deposit in which the Rexroad fauna is found has an important bearing on the question of the climate in southwestern Kansas during Blancan time, for, as Hibbard notes, *Sorex taylori* "was not a desert form, but one that lived along the streams and in the marshes, apparently in habitats similar to those in which the majority of the species of *Sorex* live at present. The closest points of known occurrence today are about three hundred miles away in northwestern Nebraska and the edge of the Rocky Mountains in eastern Colorado," hence it would seem to indicate that a lower summer temperature and a slightly more humid condition characterized southwestern Kansas in the Blancan, with the winters probably no colder than at present, with probably a greater rainfall.

A little later than the Rexroad are the Pleistocene deposits containing the Cudahy, Sunbrite, Wilson Valley and Tobin faunules of Meade County. In both the Cudahy and Wilson Valley assemblages, Hibbard recovered a species of shrew identified as *Sorex cinereus* Kerr. This is the oldest record of this species in Kansas and consists of parts of about thirty individuals. The species is still living though not in Kansas. Its present range extends from the Atlantic to the Pacific but is mostly north of the 41° north latitude, except in the mountains where it ranges southward to about 35°. Certain variations in these fossil specimens may mean that there are two or more subspecies represented in the Rexroad fauna, but without more complete material this cannot be certainly determined.

Three other new species of shrews have been recovered from the Cudahy faunule. One of these, called *Sorex cudahyensis* by Hibbard (holotype: KUMVP, No. 6513), was about four inches long, hence larger than *S. cinereus* or *S. taylori*. It is characterized by well-marked but technical differences in its teeth from these and other species of known shrews. Associated with the other shrews were two which are assigned to other genera. One of these is called *Neosorex lacustris* by Hibbard (holotype: KUMVP, No. 6630) and was about six inches long; it is represented by a half dozen specimens. The last species from the Cudahy faunule is called *Microsorex pratensis* by Hibbard (holotype: KUMVP, No. 6470). The genus *Microsorex* includes the smallest species of North American shrews and this species was probably only about three and one-half-inches long. Its specific characters are found in the size and form of its teeth.

Sorex cinereus Kerr again appears in the Wilson Valley faunule of Meade County, approximately equivalent in time to the Cudahy;

later in the Rezabek fauna of Lincoln County, and still later in the much younger Jones fauna of Meade County. *Sorex taylori,* first found in the Rexroad fauna, reappears in the Pleistocene Interglacial, Borchers fauna, of Meade County.

Order Chiroptera: Bats:

These are mammals with the fore limbs developed as wings, in which the fingers are greatly elongated, supporting a large expanse of skin that extends backward alongside the body to include the leg and usually the tail also. The breastbone (*sternum*) is generally keeled, as in the flying birds, for the attachment of the large pectoral muscles used in flight. The North American forms are wholly insectivorous, at least in the United States, and the form of the teeth is very similar to that of the shrews.

Only one fossil bat has been recorded from Kansas. It was about the size of the common living Cave Bat, *Myotis velifer* (Allen), the largest species of the genus occurring in the United States. The fossil specimen, now in the University of Kansas Museum of Vertebrate Paleontology, comes from the Blancan Rexroad fauna, of Meade County.

Order Xenarthra:

This order of mammals comprises several very distinct families, such as the sloths, anteaters, and armadillos, as well as the extinct ground-sloths and glyptodons. The group is so distinct from all other mammals that some students have maintained that a separate *subclass*—the *Paratheria*—should be erected for it. The teeth are all nearly alike in form, there being no differentiation into incisors, canines, premolars and molars, and there is only one set, *i.e.,* there is no deciduous set preceding the permanent teeth. They are always *hypsodont,* that is, rootless and growing from the base as fast as the crown wears away from use above, and the enamel is often lacking. The ground-sloths—the only branch of the order known as fossils from Kansas—have the type of dentition and general form of head found in the living sloths of South America, but with the body and limbs more like those of the anteaters. The *Order Xenarthra* (from the Greek meaning "strange joints"), is so-called because of certain peculiar processes of their posterior trunk vertebrae, in addition to the so-called zygapophyses found in all other eutherian mammals. "In the hinder part of the dorsal region, there appears an additional pair of articular processes, and these increase in number posteriorly, until, in the middle of the loins, there are

no less than four accessory pairs (making ten in all). Such an elaborately complex mode of articulation is altogether unique among mammals" (Scott).

The ground-sloths known from Kansas are placed in two families—the *Megalonychidae* and the *Mylodontidae,* all members of which are extinct. All the known species are of comparatively large size, some almost elephantine in dimensions. The genus *Megalonyx,* first described by Thomas Jefferson in 1797, is much smaller than any of the *Mylodontidae,* the second family occurring in Kansas. It was apparently a forest-dwelling creature, and ranged from northeastern Ohio, Kentucky, and Tennessee to California. It is known only from North America, though it probably arose in South America and likely migrated northward, reaching this country in the Pliocene. The only complete skeleton known is in the museum of Ohio State University and measures eleven feet four inches in length to the end of the long tail. It has five teeth above and four below on each side; the first tooth in each jaw is separated by a considerable space from those behind it and has the form of a short tusk. It was hypsodont and the crown was worn down by use in feeding. The remaining teeth were grinding in function and have the form of more or less triangular prisms, with the base of the triangle internal above and external below, except in the case of the last tooth which is almost quadrangular. In mastication the crown surface of the grinding teeth is concave with the margin of harder dentine raised.

In the skull the facial portion is very short and the brain-case very long. There is a distinct sagittal crest not present in other North American genera of ground-sloths. A characteristic feature is the presence of two vertical projections on the "cheek bone" (jugal), a dorsal one behind the orbit of the eye, and a vertical one which is very long, thin and plate-like, descending to the ventral border of the lower jaw, the two halves of which are fused into one in front. The hand has five fingers, all but the fifth provided with very large claws, which suggested to Jefferson the name *Megalonyx.* They were to a considerable extent retractile like the claws of a cat. In the foot, the heel bone (*calcaneum*) is very peculiar in form and "is the strangest bone of a very strange skeleton and . . . looks more like the pelvis of a moderate-sized animal than it does like a heel-bone" (Scott). The structure of the foot indicates that this animal walked, like other ground-sloths, "on the outer edge of the foot, with the sole perpendicular and facing inward. The first digit was

absent, the second and third had claws, but not the fourth and fifth upon which the weight rested" (Hay). Though nearly a dozen species of *Megalonyx* have been named, there may really have been but one—*Megalonyx jeffersoni*—in the Pleistocene. The specimens so far recovered are mostly too fragmentary to determine how much the differences may be due to ordinary sexual or individual variation.

One specimen, described by Lindahl as *Megalonyx leidyi*, represents this genus in Kansas and came from the McPherson formation, Pleistocene, in Harper Township, McPherson County. It is a skull found in a sand-pit, probably in the Sheridan beds, and is in the collection of Bethany College at Lindsborg. Cragin's record of the same species from the Meade formation, Cragin quarry, Meade County, seems to have been a misidentification; it was probably a species of *Mylodon.*

The family *Mylodontidae* is made up of animals which are half as large again and consequently much heavier than *Megalonyx*, and was the predominant family of the Xenarthra in the Pliocene and Pleistocene of South America, and the Pleistocene of North America. The type genus, *Mylodon*, was common in the latter epoch in both continents. It was apparently mostly an open-plains animal, in contrast to the forest-living *Megalonyx*, though extending into the forested regions of eastern North America to Pennsylvania, but was most abundant in the west, occurring there from Nebraska to Mexico and along the Pacific coast of California. Complete skeletons of *Mylodon harlani* have been recovered from the Rancho La Brea asphalt pits, near Los Angeles, while the loëss of northern Nebraska has yielded a perfect skeleton of *Paramylodon garmani.* In both North and South America remains of these or closely related genera have been found in caves with pieces of skin covered with hair, and thick deposits of their dried dung occur in the same locations. It is even possible that man was responsible for the death of these particular specimens. The skull is short and broad but lacks the sagittal crest found in *Megalonyx.* The downward projecting process of the cheek-bone (*jugal*) is rather broad and curved. The first three fingers of the hand are provided with the same sort of large, partly retractile claws seen in *Megalonyx.* The third claw is much larger than the others. Its hind foot is much like that of *Megalonyx* and the weight was carried on the fourth and fifth toes, with the sole of the foot facing inward.

The two genera, *Mylodon* and *Paramylodon,* may be distin-

guished by the absence of the first upper tooth in the latter, which also had a more elongated skull and an enlarged muzzle.

In 1895 Williston figured and described a fibula of what is probably *Paramylodon garmani,* found in digging a well in Seneca, Nemaha County, thirty feet below the surface. Cragin's find of xenarthran teeth and possibly other parts on Spring Creek, four miles southwest of Meade, Meade County, seems referable to *Mylodon harlani* Owen. This same species has also been reported from the McPherson formation in McPherson County. All these finds are, of course, from Pleistocene deposits.

Order Proboscidea:

The *Order Proboscidea* poses at present a very difficult problem in classification, if one goes back of the two or three living species, for the fossil types comprise such a bewildering array of forms, interrelated in a most complex fashion, and displaying such a high degree of individual variation, that the most experienced student of the group finds it hard to thread his way through the maze. Agreement upon generic or even higher categories in classification has not yet been reached in all cases, so that the nomenclature is in hopeless confusion for one who is not a specialist in the order. Fortunately for our purpose here, we can limit our discussion to only two outstanding divisions, *i.e.,* the mastodons and the mammoths. These two suborders are most easily separated by the form and structure of the cheek-teeth. In the mastodons, these teeth present a small number—usually three to six pairs—of large, almost conical cusps (hence, the name, from the Greek *mastos,* the breast), while in the "true" elephants, which include the mammoths, there is a series—12 to 30—of high, thin, transverse enamel ridges or crests. The teeth of the mastodons are low-crowned (*brachyodont*) and rooted; those of elephants, high-crowned (*hypsodont*) and rootless. (See figure 1).

The proboscidians appear to have originated by the Middle Eocene in the Fayûm district of Egypt, for, there, have been found relatively small forms which are ancestral, or at least related, to the later genera. Thence they migrated into other parts of the world, and by the middle or later Cenozoic had spread over Europe, Asia and North America, and a few even entered South America. Among the extinct species in the Pleistocene are some that were the largest *land mammals* that ever lived, finding rivals in size only in the extinct Titanotheres of North America and one huge rhinoceros in Asia.

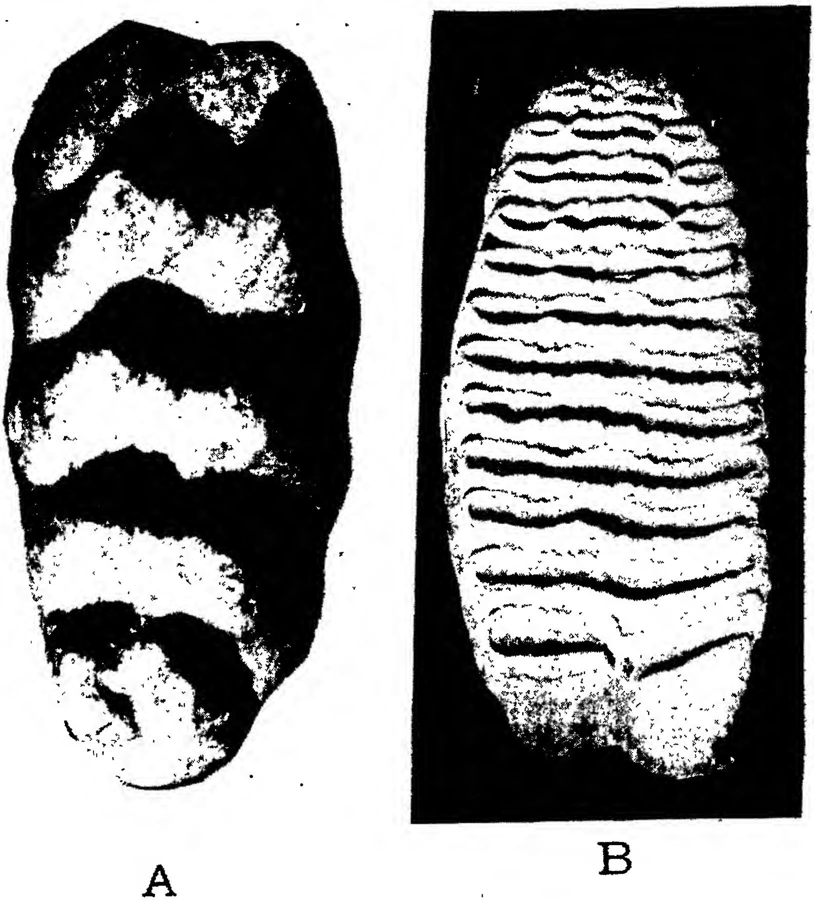


FIG. 1.—Proboscidian molar teeth; 1a, Mastodon; 1b, Mammoth.

In the course of their evolution, the changes in the body and limbs were slight, except for an increase in size; but in the head and teeth, the modifications, in addition to growth in size, were truly spectacular.

Among the more notable modifications in the head is the development of the nose into a large, muscular, very flexible trunk or "proboscis", with the nostrils situated at its extremity. A prehensile finger-like process lying above and between the nostrils is

used in grasping small objects such as leafy twigs or bunches of grass. The teeth comprise ever-growing incisors of large to huge size—never more than a single pair above and below, and often borne by the upper jaws alone, which project largely out of the mouth and constitute the familiar "tusks". They are elongated, usually conical, and generally more or less curved. They are mainly composed of dentine—the "ivory" of commerce—with the enamel restricted to the tip of the tusk, or, in some species, forming a longitudinal band of small width. There are no canine teeth. The cheek-teeth, *i.e.*, the premolars and molars, in the mammoths, have greatly elongated transverse ridges which are surrounded and supported by a large mass of "cement", which fills up the valleys completely. With wear the grinding surface of the tooth is found to consist of alternating layers of varying hardness—cement, dentine and enamel —which produce a fine and very efficient sort of "mill-stone" for reducing the food to a pulpy consistency. The mode of succession in these teeth is very peculiar. During the life-time of the animal there are never more than six functional grinding teeth on either side, above and below, with occasionally another vestigial one in front. The last three are true molars, such as occur in other mammals, but those in front of these are the milk-premolars which are never replaced by permanent successors. The entire series of the cheek-teeth moves forward in the jaw gradually, as those in front wear away from use and their remnants are cast out, while those behind are undergoing their development within the jaws. The individual teeth are so large and their growth and erosion occur so slowly that usually only one, or portions of two teeth are in place and functioning on either side above and below at one time. Usually this whole series of changes corresponds with the life-time of the animal. In the mastodons, where the teeth are smaller and simpler, there may be as many as three or four teeth in functional use at one time and the growth is in a vertical direction, rather than forward as in the true elephants. As Romer remarks, "parenthetically, it may be noted that, while teeth are the most common remains of fossil elephants, their interpretation presents difficulties. The appearance of the ridges varies with the degree of wear. The number of plates not only differs from form to form but even more widely from tooth to tooth of the same individual; the premolars are relatively simple, the last molars most complex."

Classification: A greatly simplified classification of the fossil proboscideans of Kansas, open to objection on technical grounds by

taxonomists, but convenient for our purpose, is adopted here as follows:

Order Proboscidea
- Suborder Mastodontoidea, mastodons
  - Family Trilophodontidae
    - Subfamily Trilophodontinae
      - Genus: *Trilophodon*
    - Subfamily 2. Tetralophodontinae
      - Genus: *Tetralophodon*
    - Subfamily 3. Rhynchotheriinae
      - Genus: *Rhynchotherium*
    - Subfamily 4. Gnathobelodontinae
      - Genus: *Gnathobelodon*
    - Subfamily 5. Amebelodontinae
      - Genus: *Amebelodon*
  - Family Stegomastodontidae
    - Genus: *Stegomastodon*
  - Family Serridentidae
    - Genera: *Ocalientinus, Serridentinus*
  - Family Mastodontidae
    - Genera: *Pliomastodon, Mastodon*
- Suborder Elephantoidea
  - Family Mammuthidae, mammoths
    - Genera: *Mammuthus, Parelephas, Archidiskodon*
  - Family Elephantidae, elephants *sensu stricto*
    - Genera: *Elephas, Loxodonta* (non-Kansan).

Family Trilophodontidae:

The family of mastodons called the *Trilophodontidae* first appeared in Europe in the Lower Miocene, very likely as immigrants from northern Africa, represented by the type genus, *Trilophodon* itself. It invaded Asia during the Upper Miocene and reached the Great Plains of North America in the Lower Pliocene. The name of the genus was suggested to Falconer, who first described it, by the presence of *only three* transverse rows of cusps on the fourth premolar and the succeeding first and second molars. The third, or last, molar, has *four* such cross-rows of cusps. Small conelets, which when worn by use present a *trefoil* design, occur in the valleys between the main crests of the molar teeth. Such teeth are clearly adapted for browsing, the animal feeding on twigs and leaves, rather than grass.

In this family the jaws are very long, in some species reaching the extraordinary length of 6½ feet, thus equalling or even exceeding the height of the animal at the shoulders and enabling him to rest his "chin" on the ground! There are four projecting tusks, two upper and two lower, which are the modified second incisors on each side; the first incisors are lacking. The two rami of the lower jaw, which are united anteriorly in a very long symphysis, bear on either side a powerful tusk, triangular or subcylindrical in cross-section. These

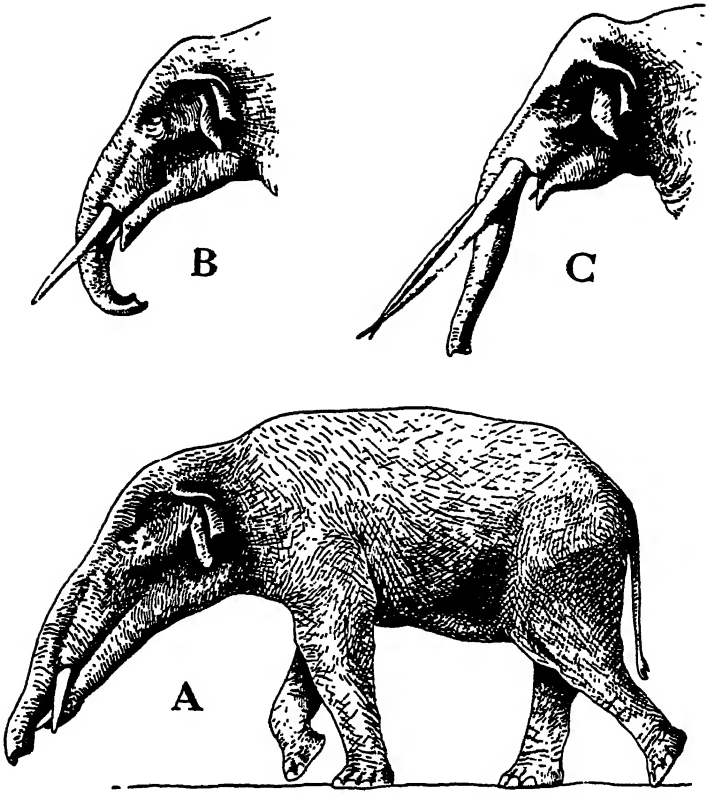


FIG. 2.—Early Mastodons: 2a, Trilophodon; 2b, Tetralophodon; 2c, Stegomastodon. Modified from Abel.

two lower tusks gradually became appressed in the median line of the jaw so closely that they functioned as a single tool, undoubtedly being used more or less as a shovel in digging up plants for food. The short upper tusks were more conservative though they curved downward to a marked degree and were used as weapons of offense and defense. (Fig. 2a).

In this country *Trilophodon* diversified into a number of species and culminated in the huge *T. giganteus* of South Dakota, which lived into the very late Pliocene, if not actually to the close of that epoch. A species named by Andrews in 1909 as *Trilophodon dinotherioides* was based on a specimen recorded merely as from "northwestern Kansas". As the specific name indicates, the tip of the lower jaw and its tusks are bent downward to such an extent as to remind one of the Old World genus *Dinotherium,* which does not occur in

North America. A second specimen of *Trilophodon,* species undetermined, has been recorded by Hibbard from the Blancan formation, Rexroad fauna, of Meade County. Proboscidean remains had evidently been abundant at the locality where Hibbard secured his specimens, but the large size of the bones had attracted the interest of the workers in a CCC camp there, who had removed them and had carried them away to parts unknown. Among the fragments overlooked by these workmen, Hibbard found four molar teeth, all belonging to *Trilophodon.* These are now in the University of Kansas Museum of Natural History, catalogued as follows: No. 3860, two molars; No. 3861, an upper molar; and No. 3862, a third molar.

Tetralophodon is a genus which is most likely a direct derivative of *Trilophodon,* from which it may be distinguished by the presence of *four—not three*—transverse crests on the anterior molar teeth. It appeared in Europe (Germany and Greece) in the Lower Pliocene, and at about the same time in Asia (India). It reached North America in the Pliocene and survived here until the Pleistocene. Its lower jaw is somewhat shortened and the lower tusks do not touch each other in the median line, but diverge somewhat anteriorly. The upper tusks are longer than those of *Trilophodon,* and are practically straight. (Fig. 2b). One species, *Tetralophodon campester,* was described by Cope, from the bank of Sappa Creek, Republican River formation in southeastern Rawlins County, and is now, presumably, in the American Museum of Natural History in New York City. It was a rather stout form, six feet or over in height at the shoulders. The rami of the lower jaw are united in front by a very long symphysis, and while the intermediate molars are tetralophodont, the last molar has *six* cross-rows of cusps with a posterior "heel" in addition.

One divergent branch of the *Trilophodontidae* is that of the "beak-jawed" mastodons, or *Rhynchotheriinae,* represented in Kansas by one or two species of the typical genus *Rhynchotherium.* In this genus there is a broad band or ribbon of enamel on the outer side of both the upper and lower tusks, but the peculiarity in structure that gives the name to this genus and its subfamily is the enlarged end of the lower jaw which bends down to form a "beak"; in correlation with this feature, the lower tusks also curve downward rather sharply, again suggestive of *Dinotherium,* a form confined to the Miocene and Pliocene of the Old World. The upper tusks are rather short, stout, and but little curved.

Rare in North America from Montana and Nebraska to California, these rhynchotheres become more abundant southward and

are rather common on the Mexican plateau. No member of this subfamily is known to have crossed the Mississippi. *Rhynchotherium,* which ranged from Africa to North America, was one of the first mastodons to reach this continent, where it persisted from the Middle Miocene to the Pleistocene. One species is *Rhynchotherium euphypodon,* the type of which, consisting of only a part of an upper jaw (*maxilla*) with tusks and the associated lower jaw (*mandible*), was recorded by Cope "from Kansas", exact locality not given, but probably from the Republican River. The upper tusks have an inward and forward rotation, so that their tips tend to come together. Their enamel bands are somewhat on the outward side at the base but come to lie on the under side at the tip. In cross-section the tusks are round to oval. Another species, also recorded from the "Uppermost Pliocene of western Kansas", was named by Cope *Rhynchotherium dinotherioides.* It is too fragmentary and too little known to merit discussion here.

In a species from California, *Rhynchotherium edensis* Frick, the type specimen is more complete and reveals an adaptation in the use of the tusks. As reported by Frick:

"This adaptation suggests an hypothesis as to there having been a shear-like action between the respective inferior and exterolateral enamel bands of the opposed upper and lower tusks. . . . An examination of the wear of the opposed tusk surfaces suggests that the upper pair of tusks crossed the lower pair some six inches behind the tips of the latter, and thus the downward directed tips of the upper tusks only slightly cleared the external edges of the lower pair. . . . The relatively far greater wear of the upper right tusk shows that this particular individual was very definitely 'right-handed.' The study of the surfaces of the opposed pairs of the incisors [i.e., the tusks] . . . suggests that *Rhynchotherium* may have subsisted largely on the vegetation of marshes and ponds, its shear-like incisors and depressed mandibular symphysis possibly being adapted to the quick-severing of the slimy roots of succulent water-plants."

A second aberrant subfamily of the *Trilophodontidae* is that called the *Gnathobelodontinae,* of which the genus *Gnathobelodon* includes one species, *G. thorpei,* the type of which is in the Fort Hays State College. It was collected near the town of Ogallalah, in Trego County, about 20 miles west and 3 miles north of Hays, Kansas. This is a "Spoon-bill Mastodon", since the lower tusks are wanting and the mandible anterior to the molar teeth is greatly elongated, expanded toward the tip and spoon-shaped, the jaw bones thus form-

ing a shovel with a thin edge. "Such a jaw can only have been used as a mud digger, perhaps scooping up aquatic plants from shallow ponds" (Scott). It is difficult to understand the adaptation presented in this strange form of the lower jaw, since there is no living animal in the least like this Pliocene mastodon. Barbour, who

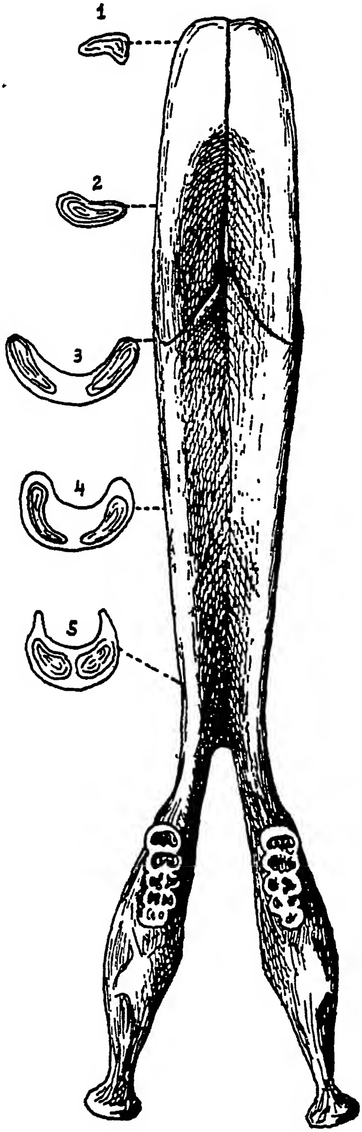


FIG. 3.—Lower jaw of Shovel-tusked Mastodon, Amebelodon fricki. From Barbour.

first discovered the "Spoon-bills", interprets this structure as being "presumably for the attachment of a coarse, heavy, gristly pad, usable perhaps in tearing leaves and twigs from branches", or, as Scott suggests, "it may have been a horny digging apparatus."

The Kansas specimen was found in coarse, cross-bedded channel gravel, about 12 to 14 feet below the surface. The gravel deposit at this point is 22 feet thick and is overlain by 4 feet of dark clayey soil.

The fifth subfamily of the *Trilophodontidae* recorded from Kansas is that called the *Amebelodontinae,* represented in this state by the widely distributed and well-known species, *Amebelodon fricki* Barbour. (Fig. 3). In the genus *Amebelodon* the lower, or mandibular, tusks are flat instead of cylindrical and the two together form a broad and effective spade or shovel for digging up plants. A specimen in the University of Kansas Museum of Vertebrate Paleontology (No. 3852) from Wallace County is of special interest and importance since it comprises the first set of upper molars of *Amebelodon* to have been found and figured. From Barbour's account of this specimen we extract the following facts:

The upper molars of Amebelodon "are encircled by a cingulum [i.e., a narrow marginal ledge on the crown of a tooth] which is generously developed, and well marked by cones, especially on the inner border. The second molar, $M^{\underline{2}}$, has four coarse, trefoiled lophs, or grinding ridges, and a heel. . . . The third molar, $M^{\underline{3}}$, . . . exhibits six coarse lophs and a heel. The grinding ridges are composed of strong inner and outer cones with smaller intermediate ones. The cones, especially on the inner border, are so deeply and regularly corrugated as to constitute apparently a diagnostic character. The enamel of these teeth is thick and whitish and in the valleys there is a little scattered cement."

So far as I am aware, the upper tusks of *Amebelodon* and the post-cranial skeleton are unknown, though Barbour infers that "the excessive development of the mandible of this progressive amebelodont gives support to the conception that the upper tusks may have been dwarfed, or possibly aborted."

The extraordinarily long and slender mandible presents some puzzling problems to an anatomist. In cross-section it is concavo-convex, with the convex surface on the lower side, and the two rami are fused in the median line to form an excessively long symphysis. Where the tusks emerge from the jaw-bone, the latter is

10¾ inches broad; about 29¼ inches posterior to this point is the posterior end of the symphysis, where the two rami diverge behind. At this level, the jaw is only 7½ inches broad. This is the point where the huge mandible is narrowest and weakest, and yet it is the point of greatest stress and strain. Barbour raises the question: "How could the jaw have functioned as a shovel when at its narrowest point it shows such structural weakness? The mandible seems none too strong for the support of its own load and altogether inadequate to perform work, nevertheless the conviction remains that the broadened tusks and flared mandible functioned in some way as a shovel. The great leverage as well as the apparent structural weakness must be taken into account. Possibly the trunk was wound around this unique shovel jaw to give it muscular reinforcement." Moreover, it seems clear, as Barbour has pointed out, that "the shovel-mastodon must have carried its head high in order that the protruding mandible could clear the ground, and not interfere with progression."

The molar teeth are large, being 9 inches long by 3½ inches wide, and each has *five* broad transverse grinding ridges with a distinctly trefoiled pattern.

Several fragmentary specimens of *Amebelodon fricki* have been recorded from the Rhino Hill quarry, Middle Pliocene, of Wallace County (KUMVP, Nos. 3852, 3853, 3854, 3858, 3477 and 2865); another (KUMVP, No. 2864) is from a sand-pit two miles north of Wakeeney, Trego County, also Middle Pliocene in age; and still another (KUMVP, No. 2863) from a site eight miles northwest of Ashland, Clark County, again in the Middle Pliocene. Hibbard records its occurrence also in the Blancan formation, Rexroad fauna, of Meade County.

The museum of McPherson College has several parts of an *Amebelodon* collected from a gravel-pit five miles northwest of Canton, McPherson County. Although these specimens were described by Professor R. E. Mohler as *A. fricki*, they are rather larger and show other differences from that species and may eventually prove to represent another distinct form. The University of Nebraska has a fragment of a young *Amebelodon* from Clark County, Kansas, as well as two tusks of the same from Smith County, Kansas.

The second family of American mastodons is that of the *Stegomastodontidae*, represented in Kansas by the genus *Stegomastodon*. This genus is apparently the direct offspring of *Tetralophodon*, thus

continuing the line of evolutionary development begun by the Old World *Phiomia* and carried on by *Trilophodon* and *Tetralophodon.* Its lower jaw is still shorter than that of the last named genus, so that the two rami are united in only a very short symphysis in front. The lower tusks are vestigial or entirely lacking in some cases. The upper tusks are relatively slender and about twice as long as those of *Tetralophodon.* They are straight or slightly upcurved throughout the terminal third of their length. The grinding teeth of *Stegomastodon* are short crowned, and the anterior ones are shed early in life, so that the young adult has only two, and the old individuals only one molar, above and below on either side. The second molar has but three transverse crests, while the third has five to eight. These crests consist of a pair of conical cusps with secondary conules interposed between successive pairs to form a trefoil pattern, and thus to tend to block the valleys between the main cusps. (Fig. 2c).

A single specimen, originally described by O. P. Hay as *Gomphotherium elegans,* but now recognized as *Stegomastodon mirificus,* consists of an unworn last lower molar which was found in a sandpit about two miles east of McPherson at a depth of 35 feet. The sands there have been assigned to the "Equus beds" by early writers, but most probably should be considered as Middle Pliocene, possibly Upper Pliocene. This species was originally described by Leidy, the type, now in the museum of the Philadelphia Academy of Sciences, coming from northwestern Nebraska, being then assigned to the Pleistocene. According to Romer, *Stegomastodon* "persisted into the early Pleistocene in North America and even invaded South America."

The next family of American mastodons found in Kansas is that of the Serridentidae, characterized by the possession of jaws of only moderate length, and with the outer and inner borders of the molar teeth serrated. First known from the Miocene forest deposits of Europe, they migrated across Asia, through the northern part of what is now the Gobi Desert, thence into North America in the Pliocene, eventually finding their way southward even into Florida and Texas, and persisted to the very close of the Pliocene but they did not survive into the Pleistocene. A species, *Ocalientinus* (*Serridentinus*) *republicanus,* was described by Osborn, the type being recorded from the Pliocene of "northwestern Kansas". This specimen is in the American Museum of Natural History in New York City. A second specimen (KUMVP, No. 5982) is a skull secured by Hibbard in 1931 west of Phillipsburg, Phillips County.

Associated with it were the remains of a three-toed horse and the skull of a rhinoceros. The short, stout tusks in the upper jaws curve downward and outward, and each has a broad, longitudinal band of enamel on its outer side. There are two grinding teeth above on each side, with well-developed trefoil cusps. The crown pattern of these molar teeth is very complicated because of the development of numerous small conical conules, or cusplets, in the valleys between the large main cusps, and the deposition of cement around them. Exact generic and specific determination of this specimen has not been finally made.

Family Mastodontidae:

This is the family of the latest and most generally familiar mastodons. In them the mandible is short, the lower tusks vestigial or wanting, when present occurring only in the males. The upper tusks are large, generally six to eight feet, but sometimes ten feet or more in length, and curve upward and inward toward the tip with a spiral twist, and have no enamel on the exposed portions. The grinding teeth are large, two at a time in each half of either jaw, and have several cross-crests, each consisting of a pair of large transversely elongated cusps separated by a notch. Before it cuts the gum the molar crown is covered by a thick layer of enamel over which there is a thin layer of cement. The latter is soon worn away by use in crushing twigs of spruce or other coniferous species. The forehead is low, the body long with a broad pelvic region, the columnar legs short and massive. In height, the largest species, *Mastodon americanus,* did not exceed 9½ feet at the shoulders. It was covered with

FIG. 4.—Mastodon americanus, from a painting by Walter Yost, in K. U. Museum of Natural History.

long, coarse, brown hair, underlain by a thick coat of wool. The indications are that these mastodons were exceedingly numerous, for their remains have been recovered by the thousands, and Osborn thinks that "they may have been at one time as numerous as the bison". There is little doubt that they were contemporaneous with man in post-glacial time, and it is even possible that they owe their extinction here to human persecution. (Fig. 4).

Two genera of these "true" mastodons have been recorded from Kansas. The first of these is *Pliomastodon,* which may well have been ancestral to the later genus, *Mastodon.* Hibbard has described a species, *Pliomastodon adamsi* (type: KUMVP, No. 6788), from the Ogallala formation, Middle Pliocene, of Seward County. This has the distinction of being the largest known species of its genus. The genus is distinguished by the possession of large cylindrical upper tusks arising close together and lying almost parallel to each other at the base, thence curving gently upward and outward. A narrow enamel band is present on the outer side of the intra-alveolar portion of the tusk, but it does not extend to the external portion of the tusk. The lower tusks appear to have been absent. The molar teeth are wide, only moderately crested—less so than in *Mastodon*—and there are but three transverse crests on the second molar above and below. The third, or last, molar has 4½ such crests. Secondary tubercles, when present, are single and inconspicuous. The mandible is very stout, but tapers down toward the tip, and the symphysis is short. There is reason to think that the proboscis was exceptionally large. In size, *Pliomastodon adamsi* probably equalled the largest specimens of *Mastodon americanus,* with much the same proportions of body and limbs, though with a shorter upturned neck. It was as tall as the Hairy Mammoth (*Mammuthus primigenius*), but much more massive in build.

The second genus is represented by the very well known *Mastodon americanus,* the range of which extended over the entire United States and northward into Alaska, British Columbia, and Canada as far north as Lake Winnipeg, and eastward into Nova Scotia. Rare in New England, it was exceedingly common throughout most of the rest of our eastern states throughout the Glacial Period and apparently became extinct in post-glacial, or possibly even in historic time. Its remains are usually found in surface deposits above the latest glacial drift, or embedded in bogs or old glacial lakes. Several complete and many partial skeletons have been recovered, especially in Indiana, Ohio and other states east of the Mississippi. It seems

to have been most abundant in the eastern forested regions, for it was a browsing animal, hence not at home on open prairies or plains. Its molar teeth are so much smaller than those of the Mammoth, that sometimes as many as twelve, three on each side above and below, were in use at one time, and there was not the obliquely forward movement of these teeth, as they were developed, such as occurs in the "true" elephants with their immensely large molars. The long, large upper tusks are parallel and curve gently upward. the lower tusks are lacking in the female but present in the male, where they were small and sometimes reduced to a single on located in the median line of the jaw.

It is probable that the American Mastodon was known and hunted by man, since in several instances charcoal and broken pottery have been found below the level whereon its remains occur. It, like the Mammoth, was a hairy animal with a heavy undercoat of wool. Its low head, long body and short stout limbs are in distinct contrast to the form of the Mammoth. In Kansas, *Mastodon americanus* is rarer than some other proboscideans, but its fragmentary remains have been reported from Bourbon, Brown, Doniphan, Douglas, Franklin, Jewell, Lyon, Miami, Riley and Wilson Counties.

A second species, identified as *Mastodon progenium* by O. P. Hay, is represented by a complete pair of lower jaws found below the water-level in Wakarusa Creek, about 3½ miles southwest of Lawrence, Douglas County. This specimen was the first *fossil* to be placed in the University of Kansas Museum of Natural History. In it there are the broken bases of two lower tusks embedded in the anterior end of the two mandibular rami, each about 60x50 mm. in vertical and horizontal diameters respectively. Since the lower floor of the socket is somewhat convex, it is inferred that these small tusks must have curved downward. The mandible, when found, was buried in blue clay and lay at a level of about 25 feet below the present surface of the creek banks. *Mastodon progenium* is thought to have been a somewhat more primitive form than *Mastodon americanus.*

Suborder Elephantoidea

Family Mammuthidae:

The Suborder *Elephantoidea* embraces all the so-called "true" elephants in distinction to the various races of mastodons. In them the teeth are reduced in the adult to one (the second) upper incisor, which has the form of a long, massive bluntly pointed tusk, and six molars, three above and three below, on each side. In the young of

earlier forms there are three additional milk-premolars which function as true molars but are lost in the later species—in living elephants no vestiges of them are ever formed within the jaws. The tusks continue to grow throughout life and bear enamel only at the tip. The skull of an elephant is notable for its extreme shortness fore and aft, and its great vertical height. The greatly thickened skull-roof is made up of an outer and an inner plate separated by thin laminae inclosing huge air spaces, a condition which greatly reduces the weight without lessening the strength of the skull. The neck is very short, while the body is long and massive. One striking peculiarity is seen in the neck and body vertebrae, in which *all* the dorsal spines are inclined backward. The legs are long, stout, and constitute columns for the support of the heavy body. Unlike the ungulates, such as a cow or horse, the thigh bones of an elephant are very long and perpendicular in position thus bringing the knee-joint down well below the body. The hind leg thus seems to bend in a direction opposite to that seen, for example, in a horse. The feet are really digitigrade, but seem to be plantigrade, since there is a large pad of elastic tissue behind the toes, on which the weight of the body is borne. There are five digits in both hand and foot, but they do not all bear a hoof.

Two or three families may be recognized among both living and extinct forms of elephants. Only one of these, the *Mammuthidae,* or Mammoths, ever lived in America. It includes three genera, as they are generally considered, namely, *Mammuthus, Parelephas,* and *Archidiskodon.* Some authorities deem the last two as subgenera of the first, but that is a refinement in classification unnecessary for our purpose here.

Of the Mammoths, three genera have been recorded from Kansas. Of these, the best known is *Mammuthus primigenius* (Fig. 5), which is known from finds in Brown, Clark, Finney, Franklin and Lane Counties. This form of mammoth ranged in the Pleistocene from Alaska to New England along the glacial ice-front southward as far as Florida and Texas. It was an immigrant into this continent and had in fact a circumpolar distribution, being more common in Siberia and Europe than in North America. Anatômically and otherwise it is the best known of all the extinct proboscideans, for several individuals have been recovered from the frozen gravels of Siberia, in which the flesh—sometimes still edible—and the viscera were more or less perfectly preserved in Nature's cold-storage plant. We know also that this creature was very familiar to the paleolithic

FIG. 5.—Family group of Hairy Mammoth, Mammuthus primigenius; a diorama by Bernard Frazer, in K. U. Museum.

Crô-Magnon men of Europe, for they have left us spirited and detailed pictures of it on the walls of caves in southern France and nearby portions of Spain (one famous representation of this mammoth was engraved by them on a fragment of the creature's own tusk.) The males seem to have had a unique dome-shaped protuberance on the top of the head which was probably analogous in structure to the "hump" of a modern camel, since it was the result of the accumulation of fat between the top of the skull and the overlying skin. This head-dome seems not to have been developed in the females. The proboscis ended in two "lips" of equal size, there being no median finger-like process terminating the trunks, as in living elephants.

Beneath the extraordinarily thick skin (19 to 23 mm.) of the body there was a layer of fat as much as three inches thick, which served, like the blubber of a whale, to give protection against the Arctic climate in which it lived. Furthermore, the whole animal was covered by a dense growth of fine, rust-red or yellowish-brown wool, in general 1½ to 5 inches long, but longer on the legs and abdomen, where it was 10 to 12 inches in length, and in the groin, where the wool was 12 to 14 inches long. Over this wool there was an outer coat of long, coarse, dark brown hair, in some places 20 inches long, that probably served to shed rain. The short tail, only about 14 inches long, was covered with a short hair of a dirty yellow ocher in color over its basal part, and it ended, like the tail of a cow, in a tuft of stiff bristles. "The head of the mammoth is

relatively larger than in Recent elephants, permitting the marvelous growth of the upper tusks, which sometimes attained a length of 16 feet. The body is relatively short and this shortness, together with the downward slope of the back toward the rump, gave the animal a decidedly different appearance from that of other known elephants" (Scott).

The word "mammoth" has come to mean "huge" or "gigantic", but the mammoth itself was not as large as the living Indian elephant, made familiar to us by the peripatetic circus. It rarely reached a height of 9½ feet at the shoulders. It fed, as has been determined by examination of the stomach contents of the frozen Siberian specimens, upon grasses in summer and upon the twigs and needles of spruce and other conifers in winter—all plants still growing abundantly in Siberia. Its grinding teeth have 12, 16, and 24 transverse enamel ridge-plates, in the first, second and third molars respectively.

The second genus of Kansas mammoths is represented by the Columbian Mammoth (*Parelephas columbi*), reported from Bourbon, Clark, Coffey, Doniphan, Franklin, Lane, Logan, McPherson, Meade, Pottawatomie, Reno, Rush, Smith, Sumner, Trego and Wallace Counties. It may, sooner or later, turn up in many other parts of this state as well. This is certainly the most abundant species of proboscidean in Kansas. The type (No. 40769, in the British Museum of Natural History in London) was described by Falconer in 1857. The third molar in *Parelephas* has only 16-18 enamel ridge-plates; the molar crowns are broad, with enamel of intermediate thickness, more or less crimped or crenulated. The skull is intermediate in form between that of the Hairy Mammoth and the Imperial Mammoth considered below, being moderately compressed fore and aft. The mandible is short and the lower tusks are wanting. The upper tusks in old males are massive, ten to twelve feet long, decidedly curved, the tips turned in and crossed distally.

While the Columbian Mammoth exceeded the Hairy Mammoth in height and in bulk, it was not an exceptionally large form. Its range extended in general farther south than that of *Mammuthus*, and it is especially common in our southeastern states. It may not have been any more hairy than the living elephants of Asia and Africa, for it was not at home in an arctic climate, but chose rather the temperate zone where it was a denizen of the forests and savannahs. *Parelephas* is first known from the Upper Pliocene and Lower Pleistocene of Europe, and reached America sometime in the latter

epoch, but became extinct here by the close of the Fourth Glacial advance. It had therefore a fairly long time range and underwent a considerable amount of evolutionary development as shown in its several species.

A second species, *Parelephas boreus,* was recorded from Kansas by O. P. Hay from Lane and Pottawatomie Counties. The first specimen, in the collection of the Kansas State College at Manhattan, was found in loëss on the bank of Black Jack Creek, at St. George. It is characterized by thicker enamel plates than those of the species previously considered here. Another find of *P. boreus* was made by Charles H. Sternberg in his "Elephant Quarry", seven miles northeast of Pendennis, Lane County. In this find of two upper molars, right and left of one individual, there are 18 or 19 enamel crests and one or two rear "heels". These teeth are now in the American Museum of Natural History in New York City. Similar teeth are also in the University of Kansas Museum, probably also from Lane County, and probably from Sternberg's Quarry.

The third genus of mammoth from Kansas is *Archidiskodon* (type: No. 185, U. S. National Museum in Washington, D. C.), of which one species, the Imperial Mammoth (*A. imperator*), has been recorded from Graham, Ness, Riley, Rush, Russell and Sumner Counties. It well deserves its name "imperial", since it reached a height at the shoulders of 13½ feet, and in the case of a subspecies, *Archidiskodon imperator maiberni,* from Nebraska, 14 feet—thus overtopping the largest known African elephant by 2½ or 3 feet. *Archidiskodon* is first known from the Upper Pliocene of India, from which was derived the magnificent species, *A. meridionalis,* of the Pliocene and Lower Pleistocene forest deposits of Italy, France and the British Isles. It migrated to America in the Upper Pliocene or Lower Pleistocene, giving rise to *A. imperator,* first described by Leidy in 1858 from Nebraska. Its molar teeth are of a more primitive pattern than those of *Mammuthus* or *Parelephas,* the enamel ridge-plates being 17 to 19 in number in the third molar, lower and thicker, but of surprising size. The skull, however, agrees very closely with that of the other two, but continues the progressive changes seen in those two genera. It has been found along our Pacific Coast and across the Great Plains to Nebraska, Iowa and Kansas, southward to Texas and Mexico. It apparently became extinct in the Lower Pleistocene of both Europe and America, and in its disappearance exemplified once again the general principle so

frequently active among the vertebrates, namely, that *gigantism presages extinction.*

Order Lagomorpha:

This is an order of mammals formerly classed under the *Rodentia* as a suborder called the *Duplicidentata.* These are the familiar rabbits and hares, and the less generally known pikas, "coneys" or "rock rabbits". The resemblances to the rodents are more the result of similarity in habits than of actual kinship. The lagomorphs have four upper incisor teeth, whereas the rodents have but two. These four teeth comprise a large functional pair, very much like the large gnawing teeth of a rat or squirrel, except that the enamel passes around to the posterior face of the tooth, instead of being limited to the anterior face as in the rodents. They have a sharp, chisel-like cutting edge in both orders. In the lagomorphs there is an additional small pair situated *directly behind* the larger functional incisors as though butresses for their support. The lower jaw in the lagomorphs is narrower than the palatal region of the skull, so that the cheek teeth above and below are not in contact upon occlusion on both sides at the same time. In consequence, in mastication, the lower jaw moves from side to side, the two sides alternately grinding the food. The tail is always very short.

The rabbits and hares are terrestrial animals, though some make use of burrows constructed by themselves or appropriated after abandonment by other species. The hares are wholly terrestrial and their young are born fully clothed with hair and with their eyes open. The rabbits, on the other hand, occupy burrows or forms in which their young are born naked and with unopened eyes. Five species with a total of nine subspecies of lagomorphs live in Kansas. Two of these are known as "Jack Rabbits", *i.e.,* the White-tailed (*Lepus townsendii companius* Hollister) and the Black-eared (*Lepus californicus melanotis* Mearns) Jack Rabbits. The first is rare. Six are known as "Cottontails", viz., the Oklahoma Cottontail (*Sylvilagus floridanus alacer* (Bangs)); Mearns' Cottontail (*S. floridanus mearnsii* (Allen)); the Staked Plains Cottontail (*S. floridanus llanensis* Blair); the Nebraska Cottontail (*S. floridanus similis* Nelson); the Wyoming Cottontail (*S. audubonii baileyi* (Merriam)); and the New Mexico Cottontail (*S. audubonii neomexicanus* Nelson). And finally there is the Swamp-rabbit (*Sylvilagus aquaticus aquaticus* (Bachman)).*

*For the present distribution of these forms, see Hibbard's *Checklist of Kansas Mammals,* in these Transactions, vol. 47, No. 1, September, 1944, pp. 61-88.

The fossil rabbits from Kansas are ascribed to six genera, only two of which have living representatives. From the Rexroad fauna, of Meade County, Hibbard has recorded and described four genera and species, i.e., *Hypolagus regalis*. (KUMVP, No. 3923, 3924, 4572), *Pratilepus kansasensis* (KUMVP, No. 4582), *Notolagus lepuscula* (KUMVP, No. 4583), and *Nekrolagus progressus*. *Hypolagus regalis* was about the size of the living Antelope Jack Rabbit (*Lepus alleni alleni* Mearns), which does not live in Kansas, but occurs in Arizona, where its range is a northern extension of its Mexican homeland. In all probability, therefore, *Hypolagus* should be classed as a "Jack Rabbit".

Pratilepus kansasensis Hibbard (KUMVP, No. 4582) is especially interesting since it is a late survivor of a subfamily of rabbits known as the *Palaeolaginae*, which was represented by several species typical of the Oligocene epoch, but for some reason has not been found in the intervening Miocene to Middle Pliocene. "This long gap in geological time should not be interpreted to mean that these rabbits were absent during that period" (Hibbard). The chances are that more intensive and careful search will bring them to light. The characteristics distinguishing *P. kansasensis* are wholly technical, concerning the form of the teeth, and need not be given here.

Notolagus lepuscula (Hibbard) (KUMVP, No. 4583) was described by Hibbard under the name of *Dicea*, but is apparently congeneric with Wilson's genus *Notolagus*, which has the priority of earlier publication. There are some differences of size to be noted between the Kansas specimen and *Notolagus velox* Wilson from California, but these may be largely due to age. Other minor differences are noted by Hibbard which make specific distinction advisable.

Nekrolagus progressus Hibbard belongs to the same sub-family as *Notolagus*, but the fragmentary nature of the find makes it impossible to say much except that it apparently foreshadows the later genus *Lepus*. "Whether the appearance of *Nekrolagus* was early enough to give rise to the leporine rabbits, is not of as great importance as the fact that the gap between the two groups is apparently bridged by this form and shows clearly how that group could have given rise to the leporine group" (Hibbard).

Another subfamily of rabbits is that of the *Archaeolaginae*, established by Dice for an ancient group that persisted until nearly Recent time, becoming extinct in the late Pleistocene. "It was apparently a conservative group and *Hypolagus* enjoyed the largest

and longest range in time of any genus of rabbit" (Hibbard). *Hypolagus regalis* is the largest known species of its genus. Hibbard suggests that *Pratilepus* probably occupied the low land and bog areas while *Notolagus, Nekrolagus* and *Hypolagus* "lived along the hill-sides or in the plains region and frequented the area [occupied by the typical members of the Rexroad fauna] only for water or occasional crossing."

In the Pleistocene Interglacial, Borchers fauna of Meade County, species of both *Hypolagus* and *Nekrolagus* occur along with another Jack Rabbit recorded by Hibbard as *Lepus* cf. *californicus* Gray, which is representative of the group of Black-eared Jack Rabbits, one subspecies of which, *L. californicus melanotis,* is widely distributed over most of the state of Kansas. It is the common Jack Rabbit known to all citizens of this state. The fact that it most likely occurred here in the Pleistocene is indicative of its long persistence.

The last fossil lagomorph at present known from Kansas is an undetermined species of *Sylvilagus,* the Cottontail, recovered from the Pleistocene, Lower Kingsdown formation, Rezabek fauna, of Lincoln County. Nothing further needs be said about it.

(*To be continued*)

Martynia louisiana Mill: An Anatomical Study

M. W. MAYBERRY
University of Kansas, Lawrence

Martynia louisiana Mill. is a member of a genus that is chiefly tropical, with its being the only species native to Kansas. The distribution by counties indicates it to be common throughout the state except for several counties of the east third. Collections were made of several specimens in the fall of 1946 in Douglas County. In 1877, Professor James H. Carruth collected specimens from this county as reported in his Centennial List of Kansas Plants in Vol. 5 of the Academy of Science Transactions.[7] Apparently no specimens were kept. He mentions finding the plants occurring around and near gardens. It is possible these were escaped from cultivation in that some people are known to use the fruit, while young no doubt, as pickles. Specimens collected from Douglas County, are now on file in the University of Kansas Herbarium. As a weed pest *Martynia*

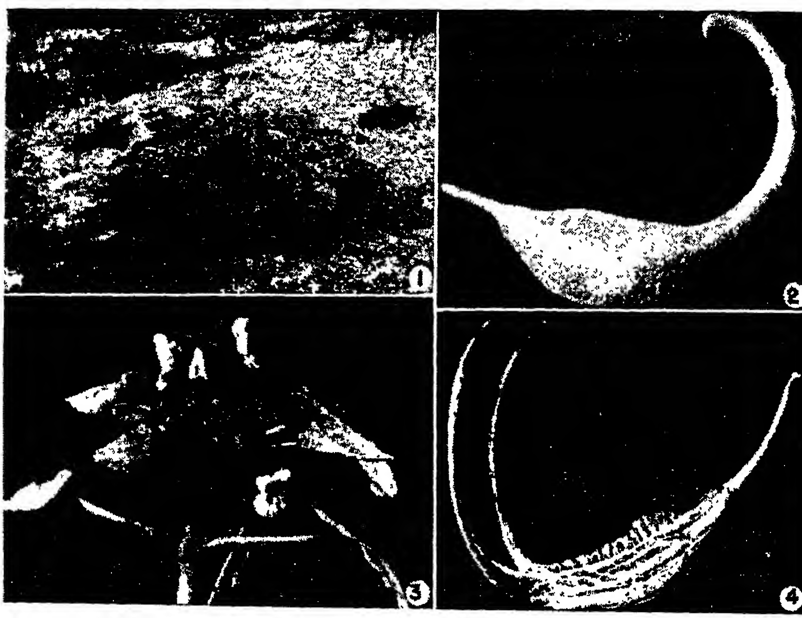


PLATE I

Fig. 1. A plant of Martynia louisiana Mill. showing growth habit.
Fig. 2. Immature fruit with pericarp intact.
Fig. 3. Portion of plant with flowers.
Fig. 4. Mature fruit. The exposed endocarp and spread claws are evident.

Transactions Kansas Academy of Science, Vol. 50, No. 2, 1947.

is widely known to farmers. The fruits with their vicious claw-like appendages, (Figs. 3 and 4, Plate I) giving the plant the common name of Unicorn plant or Devil's Claw, are the unique and most identifiable parts.

The purpose of this investigation is to place on record anatomical features characteristic of the species. No record of such kind has been found in the literature. The compiled work given in Solereder's Systematic Anatomy[8] of the Dicotyledons does not mention the family. Lubbock[1] gives the superficial features of the seedling, seed and fruit, and the sensitive nature of the stigmas has been recorded by Newcomb.[2]

Anatomical Description

Stem:

The structure is typically that of an herbaceous stem (Fig. 1, Plate II). Due to the absence of much lignified tissue, there is little woodiness exhibited. The mechanical support given the many coarsely-branched stems is due to a large amount of collenchymatous tissue and the turgidity of the mass parenchymatous cells formed in the cortex. The stem in its basal extent exhibits a solid pith but in the branches, the stems are hollow due to the break-down of the pith.

Trichomes are found in abundance consisting of two types (Figs. 5 and 8, Plate II). Glandular hairs of exceptional size and number occur as one type and are without doubt the source of the fetid odor associated with the plant. These hairs are differentiated into a stalk and head. The uniseriate stalk consists of from 4 to 5 cells, bearing a multicellular head. The head is divided solely by means of vertical walls. The other type of hairs is of the simple clothing hair form. The outgrowths are the principal distinctive features of the epidermis.

The relatively thick cortex is composed at its periphery of from nine to ten rows of tubular collenchyma. The remainder of this region consists of greatly enlarged parenchymatous cells. Fibers are absent.

The phloem occurs in discrete groupings with noticeable reductions of the tissue. Sieve tubes make up the groupings, the elements showing transverse end-walls with sieve plates limited to the end walls.

Xylem forms a continuous cylinder in that it is a part of a continuous ectophloic siphonostele. The trachery cells are diffusely placed, maceration showing them to be fiber tracheids and vessels.

The tracheids range in size from those .71 mm. in length (Fig. 2, Palte II) to shorter ones measuring .18 mm. The longer tracheids are thin-walled exhibiting irregularity in the extent of their side walls due to their tendency of following the outlines of the contiguous cells of the xylem parenchyma. The vessels are made up of short segments of the porous type (Fig. 4, Plate II). Their end-walls have simple perforations.

Pith as mentioned above breaks down early in the maturation of the lateral branches. A core of parenchymatous cells is left bounding the inner limits of the xylem cylinder.

Leaf:

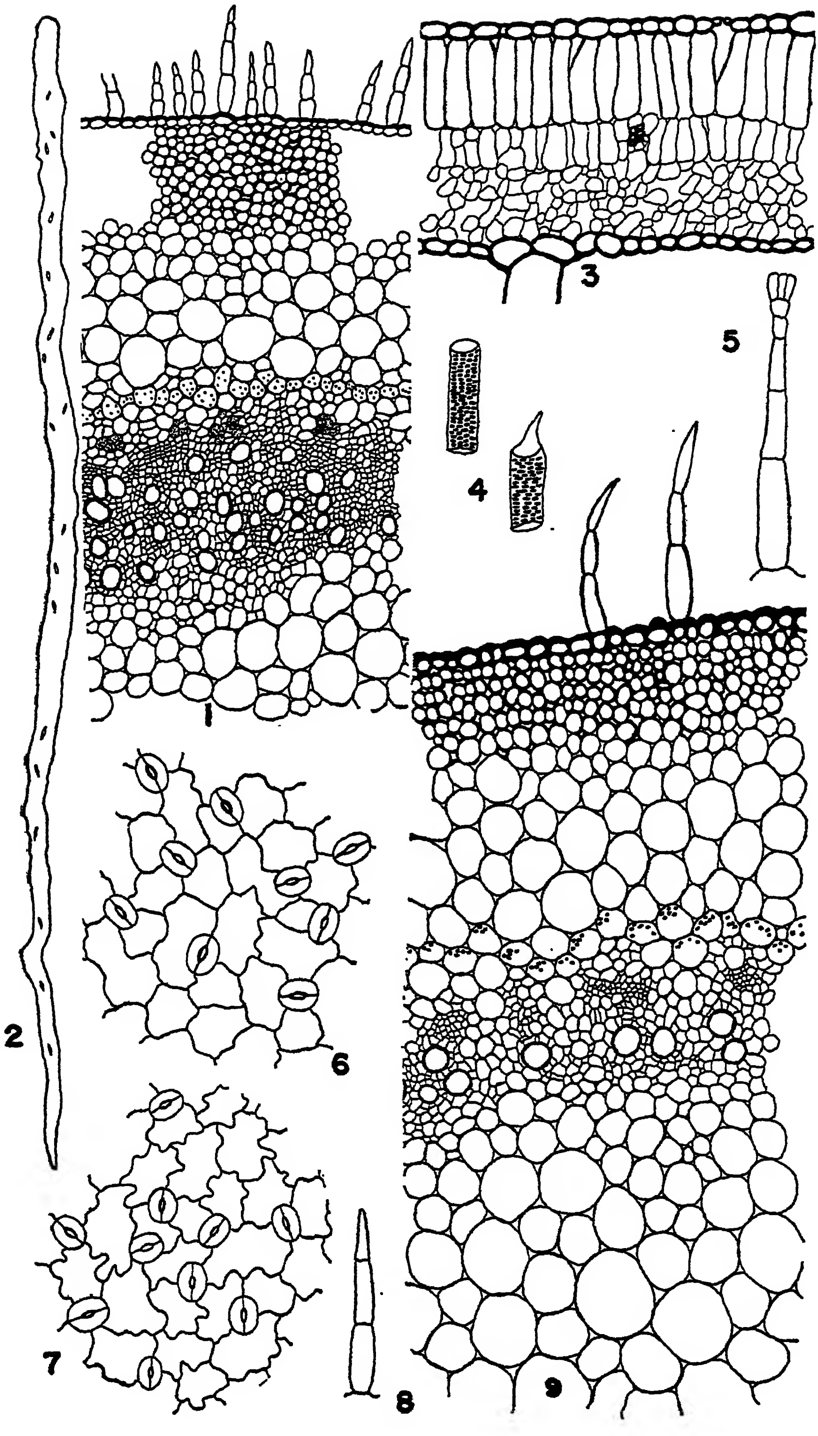
The greatly enlarged heart-shaped leaves that add to the conspicuously coarse habit of growth are supported by equally large cylindrical petioles. The epidermal surfaces of both lamina and petiole are as in the stem densely covered by both glandular and clothing hairs. Superficial views of the upper and lower epidermis of the lamina (Figs. 6 and 7, Plate II) exhibit the jig-saw pattern typical of most dicotyledons due to the undulate radial (anticlimal) walls. The cuticular layer is evident but not unusually thick. Stomata are found in both surfaces. The count is considerably below the commonly expressed average of 225 per sq. mm. of leaf surface. In *Martynia* the average for both surfaces is 30 stomata per sq. mm.

The five-nerved palmately netted veined leaves of *Martynia* have an open type venation. Vein islets average .015 mm. across and create a very efficient organization for the conduction of raw materials and synthesized products. Veins lack sclerenchyma even in the major type. Major veins project prominently from the lower surface. Cross sections give evidence of parenchyma cells with large cavities forming a greater proportion of the organization with a hypodermal layer of collenchyma one and two rows deep. The support given by these veins is thus obviously due to turgidity of the cells rather than to mechanical tissues.

The vascular organization in these veins forms a nearly closed

PLATE II

Fig. 1. Stem cross section, X 100.
Fig. 2. Stem tracheid, X 100.
Fig. 3. Leaf cross section, X 115.
Fig. 4. Tracheal vessel segments from stem, X 100.
Fig. 5. Glandular hair, X 200.
Fig. 6. Upper epidermis, surface view, X 200.
Fig. 7. Lower epidermis, surface view, X 200.
Fig. 8. Clothing hair, X 200.
Fig. 9. Petiole cross section, X 100.


1
2
3
4
5
6
7
8
9

cylinder. The xylem and phloem correspond to that described for the stem.

The mesophyll is typically that of a bifacial leaf (Fig. 3, Plate II). The palisade mesophyll is stratified into two layers. The upper strata, the most definate, makes up close to half of the total depth of mesophyll. The lower strata consists of much shorter cells, and it is in this layer that the secondary veins are embedded. The spongy parenchyma is relatively compact with asodiametric cells.

Within the cylindric petioles the tissues are closely similar to that of the stem (Fig. 9, Plate II). A hypoderm of tubular collenchyma is prominent with the remainder of the cortical region large cavitied parenchyma and starch sheath. The stellar tissues and arrangement are a replica of those found in the stem. Considering the petiole as a supporting axis to the large leaves, it is surprising to find no more mechanical tissue. However, it is apparent that its organization, combined with the cylindrical pattern, is sufficient.

Fruit:

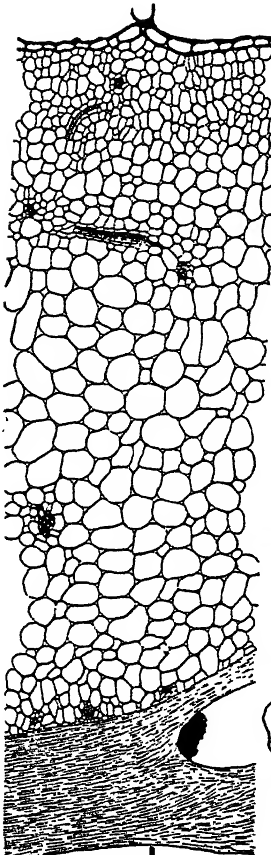
In *Martynia,* the fruit is a subdrupaceous type of capsule, one-celled, with two broad parietal placentas, many seeded, dehiscing loculicidally (Fig. 2, Plate I). At maturity, following the sloughing of superficial tissues, the fruit terminates into two long curved horns (Fig. 4, Plate I). Because of this, the name Devil's Clay has been associated with the plant. The unique method of seed dissemination, made possible by the attaching of the fruits to the legs of animals, has been commonly observed.

The tissues of the pericarp and the superficial appearance of fruit previous to a sloughing are shown in Fig. 1, Plate III. The pericarp is seen to be differentiated into exocarp, mesocarp, and a stony endocarp. As in other parts, the two types of trichomes are found scattered over the epidermis, the latter being the exocarp. The parenchymatous mass of cells containing interspersed vascular strands when sloughed leave the endocarp exposed. In this state, the surface is greatly roughened with vertebra-like extensions on the dorsal margin. The toughness and hardness of the endocarp is

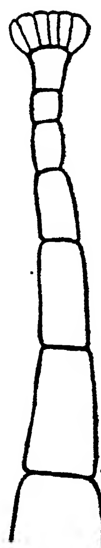
---

PLATE III

Fig. 1. Cross section through pericarp, X 11.
Fig. 2. Glandular hair from fruit, X 116.
Fig. 3. Apical view of head of glandular hair, X 116.
Fig. 4. Testa and tegmen, X 37.
Fig. 5. Base of a large glandular hair, X 116.
Fig. 6. Longitudinal diagram of seed, X 15.
Fig. 7. Section through cotyledon with aleurone grains, X 116.
Fig. 8. Section of apical region of the fruit, X 11.

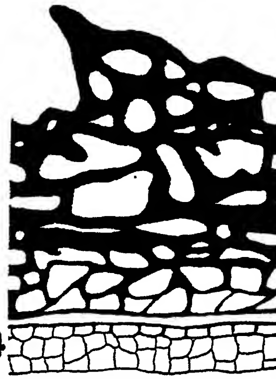


1

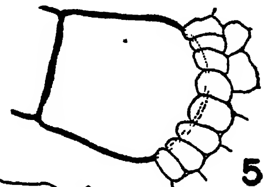


2

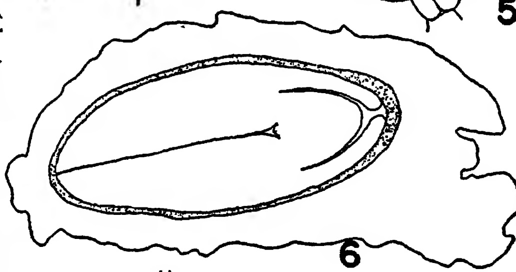
3



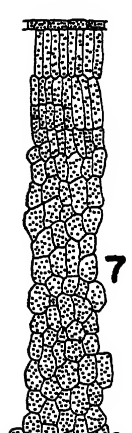
4



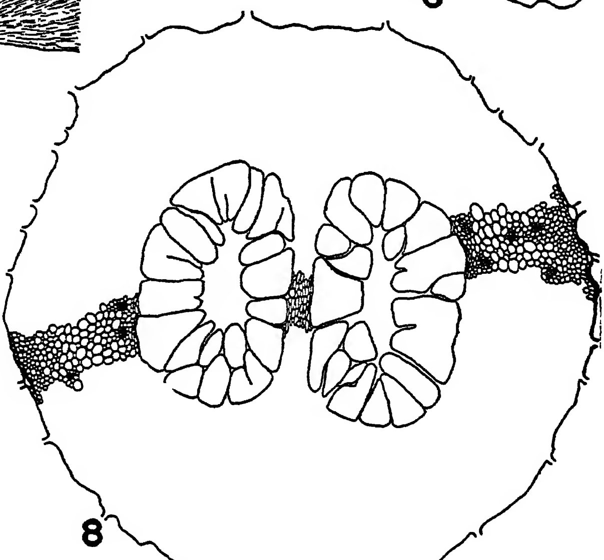
5



6



7



8

easily accounted for by sectional study. It consists of interwoven strands of lignified, fibrous sclerenchyma. The lumens of these fibers are greatly reduced due to the heavy walls. Sections through the terminal portion of the fruit (Fig. 8, Plate III) in which the large curved horns are produced show them to exist as extensions of the endocarp. The two columns of sclerenchyma are separated by thin-walled parenchyma. A study of situations indicates that the sloughing of superficial tissues of the pericarp comes about through collapse of the parenchyma bounding the endocarp. The cells become flattened and distorted as this process continues. Separation proceeds from the apex of the fruit towards the base. As the tops of the sclerenchyma columns are thus exposed, they begin to spread. This may be due to tissue tension brought about during maturation or to the dessication of the sclerenchyma from the outside progressively towards the opposed surfaces of the two columns forming the prongs.

Seeds and Seedling:

The seed is obovate, compressed dorso-ventrally with a rugose surface. The testa is thick and black, composed of large-cavitied, lignified, sclerotic cells (Fig. 4, Plate III). A thin, almost membraneous, white tegmen occurs inside the testa. The embryo is large with two fleshy cotyledons (Fig. 6, Plate III). The plumule exists as a mere fundament. Cotyledons are auricled at their bases, enclosing the short stout radicle which may only slightly protrude beyond the cotyledons. On the adaxial surface of each cotyledon are two or more layers of palisade-like cells (Fig. 7, Plate III). The rest of the tissue is parenchymatous. Micro-chemical analysis shows an abundance of oil and aleurone grains.

The seedlings as reported by Lubbock[1] are glandular-hairy all over and of considerable size. The first pair of leaves is described as being oblong-oval, smaller than the cotyledons, and like them, densely and coarsely glandular-hairy. The cotyledons are said to fall early.

Summary

1. Mesophyll of the leaf of *Martynia louisiana* is that of a typical bifacial leaf.
2. Trichomes are found on all surfaces of the shoot system.
3. Glandular hairs of unusual size are found predominate over the number of simple clothing hairs.
4. The stem organization is typically that of an herbaceous ectophloic siphonostele.

5. Sclerenchymatous fibers are about in the stem and leaf organization.
6. The pericarp is composed of exocarp, mesocarp and endocarp.
7. The prongs that spread in the mature fruit are shown to be derived from column-like extensions of the tough endocarp.
8. The cotyledons contain an abundance of aleurone grains and oil.

Bibliography

(1) LUBBOCK, SIR JOHN. On Seedlings. Vol. II. Paul, Trench, Trubner and Co. Ltd. 1892. p. 347.
(2) NEWCOMB, F. C. 1924. Significance of the Behavior of Sensitive Stigmas II. Amer. Journ. of Bot. 11: 85-93.
(3) GATES, FRANK C. 1940. Annotated List of the Plants of Kansas.
(4) ANDERSON, FLORA. 1922. Development of the Flower and Embryogeny of Martynia louisiana. Bull. Torrey Bot. Club. 49: 141-157.
(5) BAILEY, L. H. Principles of Vegetable Gardening. MacMillan Co., New York. 1921.
(6) DODGE, C. R. A Report on the Uncultivated Bast Fibers of the U. S., U. S. Dept. of Agri., Fiber Investigations, No. 6. Washington, 1894.
(7) CARRUTH, JAMES H. 1877. Centennial List of Kansas Plants. Vol. 5. Trans. Kansas Acad. Science.
(8) SOLEREDER, HANS. Systematic Anatomy of the Dicotyledons, Oxford, Clarendon Press. 1908.

Botanical Notes: 1946

FRANK U. G. AGRELIUS
Kansas State Teachers College, Emporia.

As seems fairly usual "The Unusual Was Usual" in Kansas again this year. Several items are worthy of special mention.

We really had two spring seasons as may be noted by reference to the unusual dates of blossoming, or other activities of plants listed later. Field corn was coming up on April 1. Lilacs and lilies of the valley were blooming on April 3. By May 20 the iris, rose and apple blossoms were nearly gone. Bridging the interval between the two "Spring" seasons was the common hollyhock which blossomed continuously until as late as November 9.

Worthy of special mention was the digging of a good crop of potatoes as late as October 20. These had grown from some remaining from the regular crop. The Senator Dunlap strawberry, not supposed to be everbearing, began having mature fruit in October and on November 8 there were many flowers, immature, and ripe fruits.

Capping the climax of these activities was the blooming of a *Forsythia* on December 27. All of these activities ceased abruptly on December 28 with the coming of a temperature of 20°—a drop of 50 degrees from the previous 70° of a few days preceding.

For the second year we noted numerous specimens of an agaric, *Psathyrella disseminata* Pers. and the puffball *Calvatia rubroflava* (Cragin) Lloyd. The latter was more abundant than noted before.

Quite notable were a pure white-flowered plant of the wild blue sage and the exceptionally abundant fruits on the Chinese arborvitae. We collected the alga *Anabaena* in an oxbow lake east of Emporia—the first we had ever found there. A breeze from the other part of the lake was blowing and this plant had collected in a thick pudding-like mass.

Nemastylis acuta (Bart.) Herb. displayed the most outstanding event of the year to us. Its flowers are said to be "fugacious" but we were not prepared for what happened. On March 23 we were casually aware that the prairie was rendered purplish by the innumerable blossoms of this plant. Without any particular unusual conditions of the weather intervening, on the day following there was

Transactions Kansas Academy of Science, Vol. 50, No. 2, 1947.

not one blossom of this plant to be found! This fact furnishes food for thought.

Noted below are the dates of the unusual activities observed this year. These are mostly times of blossoming. Other dates were recorded but only extremes are listed.

Thuja occidentalis	October 20
Tradescantia occidentalis	July 14
Hemerocallis fulva	November 6
Convallaria majalis	April 3
Nemastylis acuta	April 23-24
Aquilegia (hybrid)	July 7
Capsella bursa-pastoris	October 28
Philadelphus coronarius var. virginalis	November 8
Spiraea vanhouttei	October 20
Spiraea thunbergii	December 27
Fragaria (Senator Dunlap)	November 8
Abutilon theophrasti	October 28
Althaea rosea	November 9
Hibiscus trionum	October 30
Forsythia var.	December 27
Syringa vulgaris	September 25
Ipomoea purpurea	October 30
Salvia pitcheri (white flowers)	September 17
Salvia pitcheri	October 28
Lonicera tatarica	September 28
Achillea millefolium	October 8
Cirsium undulatum	October 29
Taraxacum officinale	December 27

Forage Yields (1945) of Various Native Pasture Grasses Established Artificially at Hays, Kansas, in 1941.

ANDREW RIEGEL
Fort Hays Kansas State College, Hays.

Introduction

A report of a source study of blue grama grass and the effect of different treatments of seed bed preparation and weed control on establishing stands of the grass under field conditions at Hays, Kansas, was made by Riegel[10] 1943. This study considered primarily the basal cover of the various sources of blue grama at the end of the first growing season (1941), under the different treatments of seed bed preparation and weed control. At the same time that these sources of blue grama were seeded, seven other species of native grasses were planted under the same conditions of seed bed preparation and weed control.

In the spring of 1945 it was determined that a comparative study of the basal cover and yield of these various species of native grasses established artificially in 1941 would be timely.

This paper is a report of the data collected and observations made during the summer of 1945 in connection with the above study.

Related Studies

A number of investigators have published data of a comparative nature on the yields and cover of various grasses. Some of these reports include yields under different methods of seeding, seed bed preparation, and weed control. Several of the native species reported upon in this paper have been included in the various reports.

Westover[12] 1932 and his co-workers made a comparative study of yields and seed production of crested wheat, slender wheat, and brome grass under field conditions. Under limited rainfall crested wheat grass produced the heaviest yields of the three grasses.

McTaggart[6] 1937 studied the productivity of various grasses at Canberra, Australia, among which were crested wheat (*Agropyron cristatum*), intermediate wheat grass (*Agropyron intermedium*), and smooth brome (*Bromus inermus*). These grasses were grown under similar conditions of soil and climate and subjected to diffeı ent treatments of clipping and grazing.

Hase[5] 1941 investigated the effect of clipping and weed competition upon the spread of pasture grass seedlings which included

buffalo grass (*Buchloe dactyloides*), blue grama grass (*Bouteloua gracilis*), and side-oats grama (*Bouteloua curtipendula*).

Franzke and Hume[4] 1942 determined the comparative forage yields, seedling survival and other results for numerous grasses, both native and introduced, when different methods of seeding and care of grasses were used. Blue grama, switch grass (*Panicum virgatum*) and side-oats grama were among those grasses studied.

Aikman and McDermott[1] 1943 collected comparative data on the yield of four dominant prairie grasses when grown under different soil and moisture conditions. The grasses used in their investigation were *Andropogon scoparius* (little bluestem), *Andropogon furcatus* (big bluestem), *Sorghastrum nutans* (Indian grass), *Panicum virgatum* (switch grass), and *Stipa spartea* (needle and thread grass).

Olmstead[7] 1943 studied the photoperiodic responses of the genus *Bouteloua.* The data indicated that yields of the various species were definitely affected by photoperiodic treatment, the average dry weight of both roots and tops correlating positively with the length of the photoperiod.

Wenger[11] investigated the yields of seed and forage of selected strains of buffalo grass, artificially established and irrigated. He also reported yield data from native buffalo sod under different intensities of clipping.

Porterfield[8] 1944 reporting on crested wheat grass in southern Great Plains gave comparative yields obtained from field plantings for three cool weather grasses, crested wheat grass, western wheat grass (*Agropyron smithii*), and Canada wild rye (*Elymus canadensis*). These grasses were seeded in 1942 and yields obtained in 1943 and 1944.

Stark, Toevs, and Hafenrichter[9] 1946 reported the yield obtained from various grasses seeded on abandoned farm land at Aberdeen, Idaho. The seedings extended from 1939 to 1942 and yields were obtained from 1940 to 1944 on the successive seedings. Crested wheat grass and western wheat were among the grasses studied.

Cornelius[3] 1947 reported on the effect of the source of little bluestem grass seed on growth, adaptation and use in revegetation seedings. One of the fourteen ecotypes studied was from the same source as the little bluestem grass used in the following discussion. (Accession No. 480, Manhattan, Kansas, Soil Conservation Nursery).

Most of the reports mentioned were upon cool weather grasses, while those included in this study are primarily warm weather grasses.

Establishment of Grasses

In the spring of 1941, several species of native grasses were seeded on good, fertile, upland soil in seed beds that were prepared by various methods. Different treatments of weed control were also used after the grasses began to grow. Blue grama grass seed was secured from several different sources in the Great Plains region and planted under the same conditions of soil and seed bed preparation to determine their variations in response to the same environmental conditions.

It was determined, in the spring of 1945, to use these various grasses for a study of yield, debris accumulation, basal cover, and growth increment under the same conditions of seed bed preparation. In addition to these studies, buffalo grass and three sources of blue grama were selected to secure comparative data regarding yield and cover under different methods of seed bed preparation and weed control.

Three meter-square quadrats were staked out in each species for the determining of yield by clipping and weighing the grass at monthly intervals. Additional quadrats were laid out in the three sources of blue grama grass and buffalo grass for the study of yield and cover in the different seed bed preparations and for different methods of weed control. In order to permit a fair comparison between species and treatments, old growth (debris) was clipped from the quadrats the latter part of March, 1945.

On March 27, shortly after this removal of debris had been completed, an accidental fire, aided by brisk wind, swept across the area, burning the dead grass left from previous years and the accumulation of litter on the ground, and seriously damaging the grass in the areas adjacent to the quadrats. The debris had been removed from the quadrats so the fire caused little damage to the grass in them since there was little material left to burn. The debris obtained from the quadrats was retained and weighed to determine the forage left from previous growth.

Seed Sources of Species Studied

The geographic location of the source from which the seed of the eight grass species used in this study originally came, the accession number (if supplied by the Soil Conservation Service), and

the agency which furnished the seed are indicated in the following tabulation:

Accession No.	*Species*	*Source*
KG—1262	*Andropogon furcatus* (big bluestem)	Anderson County, Kans.
KG— 480	*Andropogon scoparius* (little bluestem)	Manhattan, Kans.
KG—1581	*Bouteloua curtipendula* (side-oats grama)	Miltonvale, Kans.
KG—1246	*Bouteloua gracilis* (blue grama) (central source)	Marquette, Kans.
KG—1296	*Buchloe dactyloides* (buffalo grass)	Wellington, Kans.
G— 208	*Panicum virgatum* (switch grass)	Blackwell, Okla.
KG— 491	*Sporobolus cryptandrus* (sand dropseed)	McPherson County, Kans.
Seed furnished by Southern Great Plains Field Station, Woodward, Oklahoma		
	Bouteloua gracilis (blue grama) (southern source)	Maxwell, N. Mex.
	Bouteloua gracilis (blue grama) (northern source)	Killdeer, N. Dak.
	Sporobolus asper (tall drop seed)	Source unknown

Yield and Cover

Comparative Yields of the Different Species

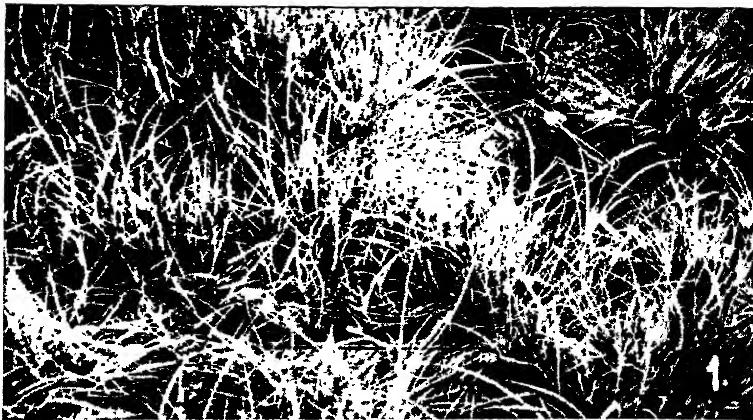
Eight different species of native grasses, consisting of buffalo grass, blue grama grass, side oats grama, big bluestem, little bluestem, switch grass, sand dropseed, and tall dropseed, were clipped four times during the summer beginning June 15, the last clipping being made September 7.

The short grasses, buffalo and blue grama, were clipped to about ½ inch, while the taller grasses were clipped at about 1 inch. In all the species studied, the largest yield occurred from the June 15 clipping. The yield of each clipping was progressively smaller to September 7 (Table I). Blue grama (central source) (Fig. 4) yielded 1842 pounds per acre and buffalo grass 2240 pounds for the season, the grasses having a basal cover of 78 and 76 per cent, respectively.

Side-oats grama (Fig. 3), with a cover of 36 per cent, yielded 1938 pounds.

Bluestems showed a much higher yield, with considerably less cover, little bluestem (Fig. 2) producing about 3315 pounds from a cover of 22 per cent, big bluestem (Fig. 1) yielding 2823 pounds with a cover of 21 per cent. Switch grass, with a basal cover of 43 per cent, produced 2840 pounds forage per acre basis.

The dropseeds showed the smallest per cent basal cover (8 per cent) of the grasses studied; yet yields of forage were high compared to the basal cover, sand dropseed yielding 1114 pounds and the tall dropseed producing 2002 pounds.



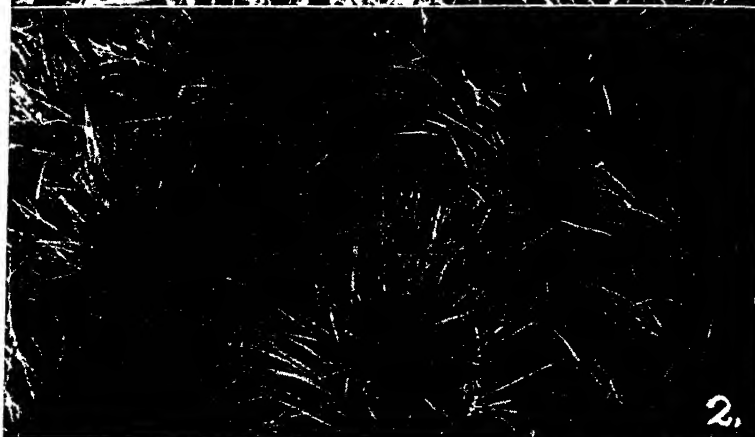


FIG. 1.—Big bluestem, on June 11, 1945, was 16.5 inches tall and had a basal cover of 22%.

FIG. 2.—On June 11, 1945, little bluestem had grown to 22 inches in height and had a basal cover of 23%.

FIG. 3.—Side-oats grama, with a height of 10 inches and a basal cover of 36% on June 11, 1945.

YIELD AND COVER OF BUFFALO AND BLUE GRAMA GRASS UNDER DIFFERENT CONDITIONS OF SEED BED PREPARATION AND WEED CONTROL

Data were collected on the forage yield and basal cover of blue grama and buffalo grass when subjected to three conditions of treatment, these being as follows:

Treatment 1. Soil was double disced to kill weeds before planting and double packed after discing. The weeds were controlled after seeding by clipping the areas with a lawn mower every two to three weeks after July 15.

TABLE I.—Per cent basal cover, yield in pounds per acre, and yield in pounds per acre per one per cent basal cover for various native grass species including big bluestem (Afu), little bluestem (Asc), side-oats grama (Bcu), switch grass (Pvi), tall dropseed (Sas), sand dropseed (Scr), buffalo grass (Bda), and three sources of blue grama; southern, central, and northern, for 1945 at Hays, Kansas. Included also are data for native mixed bluestem and short grass pastures.

Cover and Yield		Grass Species										Mixed blue-stem pasture	Short grass pasture
									Blue Grama				
		Afu	Asc	Bcu	Pvi	Sas	Scr	Bda	south	central	north		
% Basal Cover		22	23	36	43	8	8	76	35	78	70	22	85
Yield (lbs. per acre)	June	1727	2045	926	2073	1160	672	1153	638	614	511	1176	1386
	July	695	716	499	482	440	258	515	553	622	425	1333	683
	Aug.	318	431	364	238	285	131	339	414	322	246	....	....
	Sept.	83	123	159	47	117	53	232	203	285	150	747	249
	Total	2823	3315	1938	2840	2002	1114	2239	1808	1843	1332	3256	2318
Yield per 1% Cover		150	171	55	58	253	136	27	52	25	21	148	27

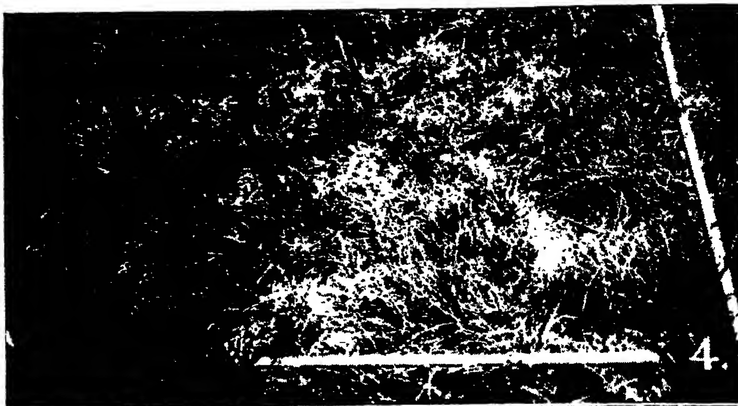
Treatment 2. No cultivation of the seed bed was done prior to seeding. Weeds were clipped with a mowing machine twice during the season.

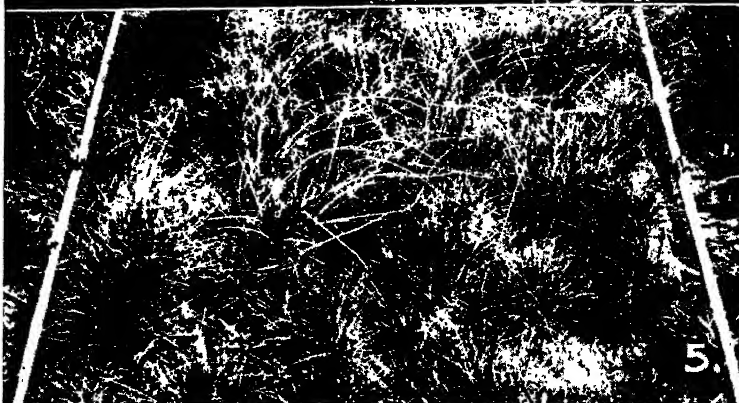
Treatment 3. No cultivation of the soil was made previous to seeding and weeds were not clipped.

After 1941 no further attention was given to the grasses in the various treatments previous to the spring of 1945 when this study was begun.

Under treatment 1, buffalo grass yielded 2240 pounds and blue grama (central source) (Fig. 4) yielded 1843 pounds, with covers of 76 and 78 per cent, respectively (Table II). Foreign grasses had invaded the buffalo grass to form about 2.5 per cent cover and yielded about 384 pounds during the season. Blue grama had only .5 per cent of foreign grasses in the area and they produced only 30 pounds of forage during the season.

In treatment 2, the cover of buffalo grass was reduced to 46.5 per cent and had been invaded by other grasses with a basal cover of 7 per cent. Buffalo grass under this treatment yielded 1636 pounds, while a yield of 1431 pounds was obtained from the invad-





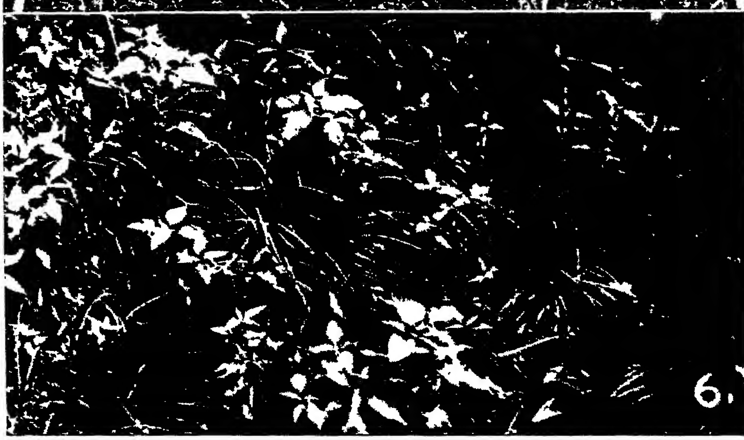


FIG. 4.—Central source blue grama as it appeared June 11, 1945, under treatment 1. It averaged 9 inches tall with a basal cover of 78%. It was nearly a pure stand of blue grama.

FIG. 5.—Central source blue grama, treatment 2, on June 11, 1945. It had attained a height of 10 inches but the cover was only 25%. Some other grasses have invaded the blue grama.

FIG. 6.—Under treatment 3, central source blue grama attained a height of only 7 inches by June 11, 1945, and had a basal cover of only 16%. Weeds and invading grasses offered the blue grama severe competition for sunlight and moisture.

ing grasses. The invading grasses made up only .5 cover in the blue grama (Fig. 5) and yielded only 107 pounds of forage. The blue grama cover was 25 per cent with a forage production of 2217 pounds.

Treatment 3 caused a further reduction in both the cover and yield of the two grasses and produced considerable competition from weeds. Buffalo grass had a basal cover of about 14 per cent and yielded 893 pounds, while invading grasses made up 4 per cent cover and yielded 787 pounds. At the same time there was produced 1883 pounds of weeds per acre in this treatment. Blue grama (Fig. 6) had a cover of nearly 16 per cent and yielded 934 pounds of forage. Invading grasses made up a cover of 2.5 per cent and yielded about 1000 pounds of forage per acre. On the same area 703 pounds of weeds were produced. When total yields of vegetation (grasses and weeds) were computed, buffalo grass yielded 2624 pounds under treatment 1, 3067 pounds under treatment 2, and 3560 pounds under treatment 3, while the yield of buffalo grass alone was 2240 pounds in treatment 1, 1636 pounds in treatment 2, and 893 pounds in treatment 3.

With regard to blue grama, total yield of the vegetation in treatment 1 was 1871 pounds, in treatment 2 2327 pounds, and in treatment 3 2636 pounds, while the yield of blue grama grass alone was 1843 pounds, 2217 pounds, and 934 pounds for treatments 1, 2 and 3, respectively.

Yield and Cover of Different Sources of Blue Grama Under Different Treatments of Seed Bed Preparation and Weed Control

Data for this comparison were obtained from plantings made with blue grama seed from three different sources representing southern, central and northern Great Plains.

The original source of the southern strain of blue grama grass was Maxwell, New Mexico, the central source came from Marquette, Kansas, and the northern source of blue grama grass was from Killdeer, North Dakota. The treatments of soil preparation and weed control are the same as previously described (page 174).

Under treatment 1, the southern source produced 1809 pounds of forage per acre with a cover of 35 per cent (Table II). Invading grasses made up a little over 1 per cent and yielded 103 pounds per acre. The central source, blue grama yielded 1843 pounds with a cover of 78 per cent and was invaded with .5 per cent (basal cover) of foreign grass yielding 30 pounds. The blue grama grass from the

TABLE II.—Summary of yields and per cent of basal cover for buffalo grass and three sources of blue grama when grown under 3 different treatments of seed bed preparation and weed control.

Grass	Species	Seed Bed, Preparation and Weed Control Treatments																	
		Treatment 1						Treatment 2						Treatment 3					
		Yield					% Cover	Yield					% Cover	Yield					% Cover
		June	July	Aug.	Sept.	Total		June	July	Aug.	Sept.	Total		June	July	Aug.	Sept.	Total	
Buffalo grass	Bda	1153	516	339	232	2240	76	758	408	270	201	1637	47	514	185	108	86	893	14
	Other Grasses	206	99	54	25	384	2.5	547	339	479	66	1431	6	436	206	104	41	787	4
	Weeds					0.0						0.0		2270				2270	
Blue grama (Southern)	Bgr	638	553	414	322	1808	35	762	487	237	61	1547	22	747	362	115	29	1253	12
	Other Grasses	42	50	18	4	114	1.5	105	112	34	5	256	1.5	654	181	25	16	876	3.0
	Weeds					0.0		128				128		332				332	
Blue grama (Central)	Bgr	614	622	322	285	1843	78	814	772	360	272	2218	25	575	223	91	45	934	16
	Other Grasses	25	0.0	3	0.0	28	.5	37	23	38	12	110	1.0	592	328	71	8	999	6
	Weeds					0.0						0.0		703				703	
Blue grama (Northern)	Bgr	511	425	246	150	1332	70	361	299	150	93	903	10	228	100	64	14	406	7
	Other Grasses	222	232	93	35	582	5.0	230	214	57	44	545	5.0	185	65	55	30	335	1.5
	Weeds					0.0		187				187		2257				2257	

northern source under treatment 1 yielded 1332 pounds of forage with a cover of 70 per cent. Invading grasses made up a cover of 4.8 per cent and yielded 582 pounds.

Treatment 2 decreased the yield (except in central source) and the cover of the blue grama from the 3 sources. The southern blue grama had a cover of about 22 per cent and a forage production of 1547 pounds. Other grasses in the area made up a cover of about 1.5 per cent and yielded 256 pounds. There were 128 pounds of weeds harvested from this area. The central source produced a cover of about 25 per cent and a yield of 2217 pounds of blue grama. Other species of grass made up a cover of .5 per cent and yielded 107 pounds of forage. Blue grama from the northern source showed a severe reduction in cover to 9.5 per cent. Production of forage for the blue grama from this source amounted to 903 pounds while other grasses made up nearly 5 per cent from which 546 pounds of forage was harvested. There were 193 pounds of weeds and forbs removed from this area.

A further reduction in the cover and yield of blue grama from each of the three sources occurred under treatment 3. Blue grama grass from the southern source produced 1252 pounds of grass from a cover of about 12 per cent. Invading grasses made up a cover of 1.5 per cent and produced over 876 pounds per acre. Over 300 pounds of weeds and forbs were produced. The central source, under this treatment, produced a cover of 15.7 per cent yielding 934 pounds of forage. Other grasses made up a cover of 2.4 per cent and yielded 1000 pounds of forage. In addition to this, 703 pounds of weeds were produced. In the northern source of blue grama under treatment 3, the cover was reduced to about 7 per cent, with a yield of only 405 pounds. Other grasses in the area made up a cover of about 1.5 per cent and a yield of 335 pounds. In this source was produced 2257 pounds of weeds.

Again comparing total vegetation, which includes all grasses and weeds harvested, the southern source of blue grama produced 1922 pounds of forage under treatment 1, 1931 pounds under treatment 2, and 2440 pounds under treatment 3, while a yield of blue grama alone was 1809, 1547, and 1252 pounds, respectively, for treatments 1, 2 and 3. Total vegetation production for the central source of blue grama for treatments 1, 2 and 3 were 1871 pounds, 2327 pounds, and 2636 pounds, respectively. The yields of blue grama grass alone were 1843, 2217, and 934 pounds for the treatments in the above order.

Total vegetation of the blue grama grass from the northern source yielded 1914 pounds under treatment 1, 2043 pounds under treatment 2, and 3000 pounds under treatment 3. Forage production of blue grama grass alone under these treatments, 1, 2, and 3, were 1332 pounds, 903 pounds, and 405 pounds, respectively.

Yield and Cover of Grasses in Adjacent Native Pastures

An ungrazed area of native grassland composed primarily of big and little bluestem yielded 3256 pounds of forage per acre in 1945 (Table I). The grasses had a basal cover of about 22 per cent. This is comparable to the average yield and cover of the two bluestems in the study (3069 lbs. with average per cent basal cover of 22.5).

Ungrazed short grass (75% buffalo, 25% blue grama) produced 2318 pounds of forage per acre and had an average basal cover of about 85 per cent. The average yield of buffalo and blue grama grass in this report was 2041 lbs. with an average basal cover of 77 per cent.

Debris and Litter

The term "debris" used in this study has reference to the dead plant material which was still attached to the plants or held off the ground by them.

"Litter" refers to the duff or dead plant material which had collected on the ground around the live plants and was detached from them.

The debris which was removed from the plots of the various grass species represented the remnants of the growth of 1944 for the most part, although some of the debris had been produced in 1943.

The weight of the debris in pounds per acre varied among the grasses from about 2500 pounds for the northern source of blue grama to 8500 pounds for switch grass (Table III). For the most part the tall grasses carried more debris than the short grasses. 4200 pounds of debris was collected from the central source of blue grama while about 3500 pounds was removed from the southern source blue grama. Buffalo grass carried about 3300 pounds debris.

The litter was measured for average depth in inches. It had reached the greatest depth under the little bluestem and switch grass where 1¼ inches were recorded (Table III). The smallest amount of litter was found under sand dropseed where only about ⅛ inch was measured. The northern source of blue grama had only ¼ inch of litter while under the central and southern sources of this grass

the litter had accumulated to about ¾ inches. The litter under the buffalo grass was about the same depth as the two sources of blue grama above.

Other species of grass in the study showed ⅜ to ¾ inch of litter accumulation.

TABLE III.—Growth increment of the various native grasses under clipping, and their seasonal growth when unclipped, and amount of litter and debris for the different species is recorded and the relation of growth increment to yield is determined. These data were obtained in 1945.

Data		Species of Grass							Blue grama		
		Afu	Asc	Bcu	Pvi	Sas	Scr	Bda	north	central	south
Growth increment by months of clipping grass (inches)	June	16.5	22	10	22	22	10.5	5	4	9	11
	July	10	8	5	8	10.5	5	4	2	6	6
	Aug.	4	5	4	4	6.5	2.5	2	1.75	5	7
	Sept.	1	3	3	0.5	6	2	1.5	1	3.5	3
Total growth increment		31.5	38	22	34.5	45	20	12.5	8.75	23.5	27
Total height unclipped grass (inches)		20	24	14	27	33	14	6	4	9.5	11
Pounds per acre per inch increment		102	101	90	71	44	55	179	152	78	67
Litter (Depth in inches)		¾	1¼	⅝	1¼	⅜	⅛	⅝	¼	⅝	¾
Debris (Lbs. per acre)		3900	4600	3900	8400	6900	2500	3300	2400	4200	3500
Ave. Lbs. per acre per 1 inch increment for grass types		Blue stem type 91				Drop seed type 50		Sod type Short grass 166		Bunch type Short grass 73	

Growth Increment

The average extent of growth of leaves and stems in each of the various grass species was recorded at the time of each clipping. Considerable variation in total increment of growth was noted; however, every species produced more growth before the June clipping than during any other period. Progressively less growth was recorded at each clipping thereafter, the least growth occurring from the August to the September clipping in every species except the southern source of blue grama. This grass grew one inch more between the July and August clippings than between the June and July clippings.

The total growth increment of each species was considerably greater when clipped than when seasonal growth continued undisturbed. The clipped areas of the taller grasses produced from 130% to 160% more total growth increment than the areas which were undisturbed. In the short grasses, the total increment of growth in the clipped areas were 200% to 247% greater than in the unclipped.

Growth accumulating before June 1 was greatest among the taller grasses. Little bluestem, switch grass, and tall dropseed had reached a height of 22 inches during this period. The southern source blue grama grew to a height of 11 inches by June 1 while the

central source of this grass measured 9 inches and the northern source 4 inches. Buffalo grass attained a height of 5 inches during the same period.

Tall dropseed produced the greatest total growth increment of 45 inches under clipping, and also attained the greatest height for seasonal growth where unclipped, averaging 33 inches. The least total growth increment under clipping was produced by the northern source blue grama, with only 8.75 inches. It also produced the least total seasonal growth where unclipped, the growth amounting to only 4 inches on the average.

Total growth increment of blue grama grass from the different sources varied considerably under the different treatments of seed bed preparation and weed control (page 176).

In treatment 1, the southern source blue grama produced a total growth increment of 27 inches, the central source 25 inches, and northern source 8.75 inches.

Under treatment 2 both the southern and central source blue grama increased in total increment of growth over treatment 1, 28.5 inches being produced by the southern source and 26 inches by the central source. The northern source blue grama under this treatment produced 8 inches.

Treatment 3 caused a reduction in total growth increment for all of the three blue grama sources. The southern, central and northern strains of the grass had increments of 25 inches, 21.5 inches and 7.5 inches respectively under this treatment.

Discussion

Climatic conditions during the growing season were about average. Rainfall from April to September totaled about 16 inches, most of the moisture coming before June 15. July and August were droughty, less than 3.5 inches of precipitation having been received during the 2 months.

This summer drought caused severe competition between grasses and weeds for moisture where the two were associated. The weeds were dwarfed in late summer and in some cases died, while the grasses were forced into dormancy. This situation prevailed particularly with the blue grama sources and for buffalo grass which were growing under the conditions existing in treatment 3. For example, the central source blue grama under treatment 3 produced about 1900 pounds of blue grama and other grasses, and 700 pounds of weeds. 1700 pounds of grass were produced before July 1, indicating that little growth occurred during the dry part of the season.

Where weeds were absent the competition was primarily among the grass plants themselves. The tall grasses produced 75 to 85 per cent of their forage before July 1. Buffalo grass had completed 77 per cent of its forage production in the same period.

The basal cover of the short grasses, with the exception of the southern source blue grama, was greater than the tall grasses but the pounds per acre of forage produced per 1 per cent cover was much greater for the tall grasses. Tall drop seed yielded over 250 pounds forage for each per cent of cover, little and big bluestem 170 and 149 pounds respectively, while sand dropseed, side-oats grama, and switch grass yielded 135, 55, and 58 pounds per one per cent cover in the order named. Of the short grasses, southern source blue grama yielded 52 pounds, central source blue grama 24 pounds, and northern source of this grass 21 pounds, per 1 per cent cover. Buffalo grass produced about 27 pounds per acre for each per cent of basal cover. The taller grass, through greater height and coarser growth, produced larger amounts of forage, while occupying much less of the ground surface than did the short grasses.

Basal cover and yield of the short grasses were affected by the different treatments of seed bed preparation and weed control.

Under treatment 1 the basal cover for the short grasses was greater than under treatment 2 or 3, and the yield (with the exception of central source blue grama) also exceeded that of the other two treatments. These grasses had the least basal cover, the lowest yield, and the greatest competition from weeds under treatment 3.

With few exceptions, the yield of the short grasses in pounds per acre per 1 per cent cover varied inversely to the total yield. The highest yields were obtained in treatment 3 and the lowest in treatment 1 under this computation. The yield of grasses apparently increased per unit area of soil covered by grass as the cover decreased when moisture was a limiting growth factor.

Total growth increment was greatly stimulated in most of the grasses by removing the top growth at intervals during the summer. When the total growth on clipped areas was compared to the unclipped seasonal growth of the various species, the ratio for the short grasses was over 2 to 1 while the taller grasses had a growth ratio 1.3 to 1 to 1.6 to 1.

The debris retained on the plants of the various species of grass and the litter on the soil under them was for the most part greater in amount for the tall grasses. Switch grass and tall dropseed had the greatest amount of debris apparently because the growth rem-

nants of two or more seasons still remained attached to the plants. The large per cent of fiber in the stems of the plants of these two species probably accounts for their remaining on the plants so long after the material was dead.

The litter under most of the species was sufficient to form an effective mulch to protect the soil from erosion and reduce the loss of surface moisture. It also tended to prevent the establishment of seedlings and growth of weeds. The gradual decay of this litter would undoubtedly enrich the soil.

The potential grazing capacity of the important pasture grasses under study when determined by the yields obtained, show considerable variation. Assuming that fifty per cent of the forage weight produced by each species of grass could be safely utilized by livestock and that 22 pounds per day was the amount of forage needed to support an animal unit, or (conservatively) produce 1 pound of gain on growing beef animals, an acre of the various grasses would support an animal unit the following number of days or produce the following pounds of gain on young growing animals.

Species	Forage for Utilization	Animal days or Pounds of gain
Big bluestem	1400	64
Little bluestem	1650	75
Side-oats grama	1000	45
Switch grass	1400	64
Sand dropseed	550	25
Buffalo grass	1100	50
Blue grama (Southern)	900	41
Blue grama (Central)	900	41
Blue grama (Northern)	650	30
Mixed bluestem pasture	1600	73
Short grass pasture	1150	52

Summary

Eight species of native pasture grasses were established artificially in the spring of 1941 at Hays, Kansas under the same field conditions of seed bed preparation and weed control. Five of the species, buffalo grass and blue grama, were subjected to three different treatments of seed bed preparation and control of weeds after seeding. Three different sources of blue grama (southern, central and northern) were used in the above study.

Data were collected from the various grasses for forage yield, basal cover, growth increment, accumulation of debris and depth of litter.

Forage yields were obtained by clipping representative areas at intervals of approximately four weeks from June to September.

Each of the grasses studied produced its greatest yield at the first clipping. Yields were progressively less for each successive

clipping. Rainfall (April to September) totaled about 16 inches with July and August quite droughty.

The short grasses produced the greatest basal cover while most of the taller grasses exceeded them in seasonal yield of forage. Sand dropseed produced the lowest yield (1100 lbs. per A.) and the lowest per cent of basal cover (8%). Little bluestem yielded 3300 lbs. of forage for the heaviest seasonal yield.

Clipping closely each four weeks was very detrimental to the continued yield and cover of all the grasses studied and was particularly severe on the taller grasses.

Under different treatments of seed bed preparation and weed control, buffalo and blue grama both responded with greater basal cover and yield where weeds were controlled by cultivation before seeding and by mowing after plantings were made. The yields and cover were least where no cultivation was made before seeding and no clipping of weeds was done after the seedlings emerged.

The heaviest accumulation of debris occurred on switch grass and tall dropseed while northern source blue grama and sand dropseed had the least. Weights of debris recorded for the grasses varied from 2500 lbs. to 8400 lbs. per acre, the average being over two tons per acre.

The litter had obtained its greatest depth (1¼ inches) under little bluestem and switch grass while under sand dropseed and the northern source blue grama it was very thin (⅛ to ¼ inch).

Monthly clipping definitely stimulated the growth of the various grasses as the total growth increment was much greater for the clipped areas than when the grass grew undisturbed throughout the season. The total growth of the clipped short grasses was 200 to 247 per cent greater than the unclipped growth, and for the taller grasses, clipping produced 130 per cent to 160 per cent greater total growth than undisturbed seasonal growth.

The sod-type short grasses produced more forage per inch of growth than the tall grasses or the bunch type short grasses. The tall grasses, other than the dropseeds, exceeded somewhat the bunch type short grasses in this respect.

The amount of forage per one per cent basal cover produced by the tall grasses was several times greater than that produced by the short grasses.

The bluestems, switch grass, and side-oats grama, with much less basal cover, produced more forage than the short grasses under about normal seasonal rainfall for this locality. The tall grasses ap-

parently would furnish somewhat more pasture for livestock (per unit area) than the short grasses.

This investigation indicates that the source accessions of the various grasses are hardy at Hays, Kansas, and can be established artificially under field conditions.

The yield data is not conclusive, but for the year 1945 the yields of the bluestem grasses in the study were comparable to those obtained in an ungrazed, mixed bluestem prairie nearby. The yields of blue grama and buffalo grass were about the same as those obtained from an ungrazed area of native short grass.

Literature Cited

(1) Aikman, J. M. and Robert E. McDermott. Comparison of dominant prairie grasses as interplanting ground covers on eroded soil. Proc. Iowa Acad. Science. 50: 235-240. 1943.

(2) Clarke, S. E., J. A. Campbell, and J. B. Campbell. An ecological and grazing capacity study of the native grass pastures in southern Alberta, Saskatchewan, and Manitoba. Dominion Experimental Sation, Swift Current, Sask. Tech. Bulletin 44, 1942.

(3) Cornelius, Donald R. The effect of source of little bluestem grass seed on growth, adaptation, and use in revegetation seedings. Jour. of Agri. Research, Vol. 74, No. 4, 133-142. 1947.

(4) Franzke, C. I. and A. N. Hume. Regrassing areas in South Dakota. South Dakota State College Agricultural Experiment Station, Bul. No. 361, 1942.

(5) Hase, Cecil L. The effect of clipping and weed competition upon the spread of pasture grass seedlings. Trans. of the Kansas Acad. of Science 44: 104-111. 1941.

(6) McTaggart, A. A study of productivity in certain introduced pasture grasses. Jour. of the Council for Scientific and Industrial Research, Vol. 10, No. 1, 17-25. 1937.

(7) Olmstead, Charles E. Growth and development in range grasses III. Photoperiodic responses in the genus *Bouteloua*. Botanical Gazette, Vol. 105, No. 2. 1943.

(8) Porterfield, Hugh G. Crested Wheat grass in the southern Great Plains. Research report (min.), Amarillo Conservation Experiment Station. 1944.

(9) Stark, R. H., J. L. Toevs, and A. L. Hafenrichter. Grasses and cultural methods for reseeding abandoned farm lands in southern Idaho. University of Idaho Agricultural Experiment Station, Bul. No. 267, 1946.

(10) Riegel, D. A. A source study of blue grama grass and the effect of different treatments on establishing stands of grass under field conditions at Hays, Kansas. Trans. of the Kansas Acad. of Science 46: 103-109, 1943.

(11) Wenger, L. E. Buffalo grass. Kansas State College of Agriculture and Applied Science, Agricultural Experiment Station Bul. No. 321, 1943.

(12) Westover, H. L. Crested wheat grass as compared with bromegrass, slender wheat grass, and other hay and psature crops for the northern Great Plains. U.S.D.A. Tech. Bul. No. 307, 1932.

A Rapid Plant Dryer

W. H. HORR
University of Kansas, Lawrence.

It seems that there is usually some uninteresting or even disagreeable task connected with all hobbies, and to those of us who collect and prepare plants for herbarium specimens there is the never ending work of changing and drying blotters. For several years I have dried all plants with a current of warm air. This eliminates all of the above mentioned work and saves at least 80% of the time ordinarily required to dry the plants after they are brought in from the field.

The apparatus pictured in Plate I, A, has been in use for five years and is quite satisfactory. The original cost was very low. The heating unit consists of an electric fan with an eight inch blade placed behind a one thousand watt heating coil. This brings the temperature of the air in the cloth tunnel up to about 50° C., depending upon the atmospheric temperature and the number of plants in the press. The higher the pile of plants, the more places there are for the air to escape thus, to a certain extent, affecting the temperature of the air.

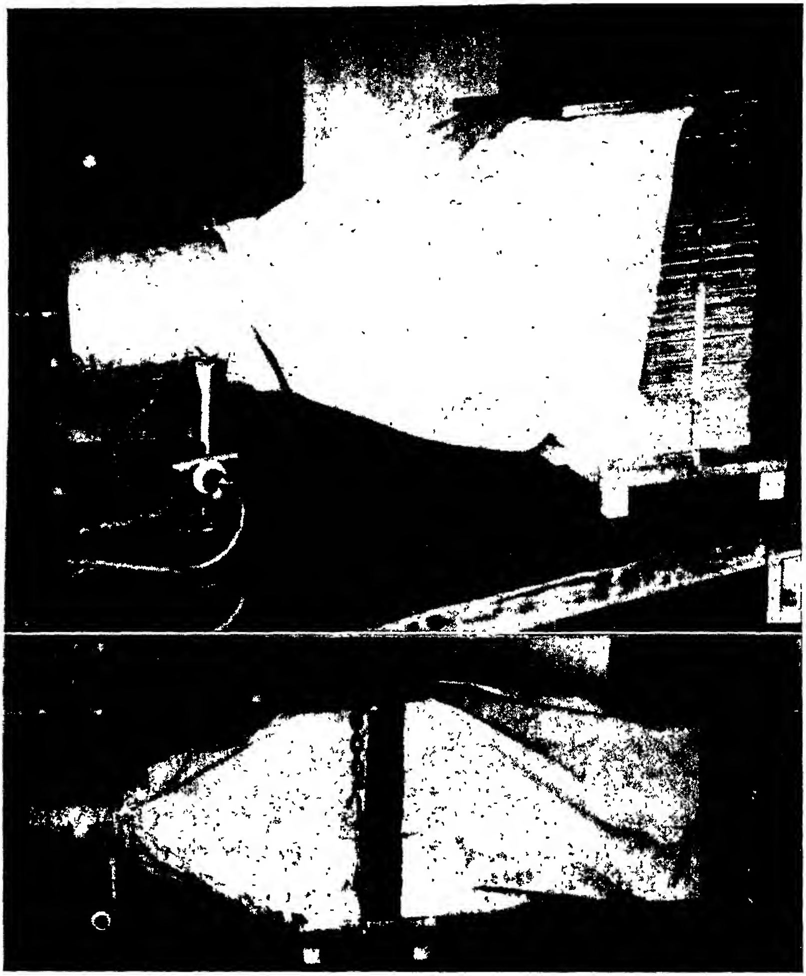
The spring on top, which keeps a pressure on the plants as they dry and shrink, is a light car spring with most of the leaves removed. A spring with a high arch is desirable.

The air tunnel is made of light weight ducking with a close weave. This can be treated to make it more nearly air tight.

The corrugated paper sheets used were made from light weight box material cut to the size of the blotters with the corrugations running crosswise. Some of these have been used for six seasons. I purchased corrugated sheets from a supply house, but they were very rough and too fragile to stand up. They are, however, more absorbent than the ones made from the box material.

In loading the press, I put down a corrugated sheet, a blotter, a plant, a blotter, another plant, another blotter, and then start over with a corrugated sheet. It is usually not advisable to put in more than two blotters with plants on them between each pair of corrugated sheets. However, if the plants are small, they can be placed as close as possible on the blotters. It is sometimes necessary to put in a pile of empty blotters to fill up the press if only a few plants are to be dried.

Transactions Kansas Academy of Science, Vol. 50, No. 2, 1947.



A Rapid Plant Dryer. (For details see text).
Upper, Plate 1-A; Lower, Plate 1-B.

The slack in the wind tunnel can be taken up by folding it on top of the blotters so that the top member of the press will hold it. After the turnbuckles are tightened, the loss of air at the ends of the blotters is practically eliminated by pinning the wind tunnel to the corrugated sheets with lath nails.

When a large number of plants are being dried, a second press can be connected to the unit. Plate I, B. It is better to let the plants in the first press get partly dry before adding the second press.

With this apparatus, the average sized plants can be dried in thirty-six hours and the small ones, in twenty hours or even less.

This apparatus, as described, is the result of a great many experiments using various temperatures and air velocities. There must be enough air pressure to keep air moving through all of the corrugated sheets at a fairly uniform rate. Otherwise, the plants in the top of the press will dry faster than those at the bottom. Small portable electric heaters with a fan were tried but were not satisfactory because of the small volume of air they move.

There are certain things which could be added to this apparatus to improve it. A thermostat in front of the heating coil would protect against possible fires if the electric fan failed. However, this has been a very usable unit and I have taken it on my collecting trips where there was electricity available.

Flowering Plants of Clay County, Missouri

L. J. GIER and WANDA PONDER
William Jewell College, Liberty, Missouri.

Clay County, Missouri, lies north of the Missouri River and east from Kansas City. The principal towns are North Kansas City, Liberty, and Excelsior Springs. Numerous small towns are scattered through the rural areas. It comprises an area of 400 square miles and was organized in 1822. It is made up of rolling hills with bluffs and limestone outcrops along the river. The soil is mainly loessal, having been deposited in early Wisconsin time, although some is covered with glacial deposits. Native flood plain forests are found along some of the streams. There are few areas of native grassland. Most of the arable land is in cultivation but probably most of the native plants have been preserved in limited numbers.

William Jewell College campus, from which most of the collections were made, is located in Liberty, near the center of the county. The campus consists of 106 acres varying in altitude from 850 to 990 feet.

Four distinct types of vegetation were found along the southeast and north sides of the campus. There is a series of habitats ranging from a swampy marsh land into grassland, small woodland, and prairie with characteristic plants for each habitat.

The present Clay County collection represents 80 families with the Compositae leading with 61 species and includes a total of 434 species. All of the plants listed herein are to be found in the William Jewell College herbarium. Occasional plants were collected during the years but a concerted effort to make a Clay County collection began in 1945. Miss Ponder collected those numbered 4376 to 4450, Lawrence Hull 4451 to 4523, and a William Jewell taxonomy class in 1947 added those from 4524 to 4583.

Dr. Steyermark spent two weeks on the campus in February and May of 1934 checking the herbarium. Dr. H. Moldenke has examined all specimens of Verbenaceae and they will be cited in his next monograph.

Gray's New Manual of Botany, seventh edition, by Robinson and Fernald was used for classification and nomenclature almost exclusively, although *Genera of Grasses of the United States* by Hitchcock, *Grasses of Kansas* by Gates, *Illustrated Flora of the Northern States and Canada* by Britton and Brown, *Manual of Cul-*

tivated Plants by Bailey, and *Spring Flora of Missouri* by Steyermark were used in identification.

Flowering Plants Collected in Clay County, Mo.

(Numbers are accession numbers in William Jewell College herbarium)

Typhaceae

Typha angustifolia L. 4451

Najadaceae

Potamogeton hybridus Michx. 158

Poaceae

Agropyron repens (L.) Beauv. 259
Andropogon furcatus Muhl. 279
Andropogon scoparius Michx. 4436
Aristida purpurea Nutt. 4376
Bouteloua curtipendula (Michx.) Torr. 303
Bromus arvensis L. 314
Bromus purgans L. 321, 322
Bromus tectorum L. 4377
Cenchrus carolinianus Walt. 4378
Cenchrus tribuloides L. 339
Chloris verticillata Nutt. 4379
Dactylis glomerata L. 4452
Digitaria sanguinalis (L.) Scop. 366, 4380
Echinochloa crusgalli (L.) Beauv. 373
Eleusine indica Gaertn. 375
Elymus brachystachys Scrib. & Ball 385, 386
Eragrostis cilianensis (All.) Link. 4437
Festuca elatior L. 4158
Glyceria striata (Lam.) Hitchc. 417, 418
Hordeum pusillum Nutt. 428
Leersia oryzoides (L.) Sw. 4438
Muhlenbergia mexicana (L.) Trin. 447
Muhlenbergia schreberi Gmel. 452, 453, 454
Panicum agrostoides Spring. 4439
Panicum capillare L. 4440
Panicum dichotomiflorum Michx. 474, 475
Panicum virgatum L. 4441
Phleum pratense L. 4381
Poa annua L. 4524
Poa palustris L. 524
Poa pratensis L. 4382
Setaria lutescens (Weigel) F. T. Hubb. 4383
Setaria verticillata Beauv. 537
Setaria viridis (L.) Beauv. 538
Sorghum halapense (L.) Pers. 4174
Sphenopholis pallens (Spring.) Scribn. 550, 551
Sporobolus asper (Michx.) Kunth. 556
Sporobolus heterolepis Gray 4442
Triodia flava (L.) Smyth 568, 570, 4443
Tripsacum dactyloides L. 571

Cyperaceae

Carex conjuncta Boott. 596, 597
Carex flaccosperma Dewey 610, 611
Carex lurida Wahlenb. 4384
Carex retroflexa Muhl. 721, 722
Carex shortiana Dewey 740, 741
Carex tetanica Schkuhr. 759, 760
Carex tribuloides Wahl. 600, 761
Cyperus engelmanni Steud. 4385
Cyperus esculentus L. 638
Cyperus strigosus L. 4444
Scirpus atrovirens Muhl. 4445

Araceae

Acorus calamus L. 189
Arisaema dracontium (L.) Schott. 192
Arisaema triphyllum (L.) Schott. 193

Commelinaceae

Commelina erecta L. 4454
Commelina virginica L. 4386

Juncaceae

Juncus tenuis var. anthelatus Wiegand 250
Juncus torreyi Coville 4446

Liliaceae

Allium canadense L. 4525
Asparagus officinalis L. 4455
Convallaria majalis L. 4526
Erythronium albidum Nutt. 843
Hypoxis hirsuta L. 4531
Muscari botryoides L. 4527
Ornithogalum umbellatum L. 4528
Polygonatum biflorum (Walt.) Ell. 4529
Smilacina racemosa (L.) Desf. 884, 885
Smilax herbacea L. 4456
Trillium sessile L. 4530
Uvularia grandiflora Sm. 928

Dioscoreaceae

Dioscorea villosa L. 935

Iridaceae

Belamcanda chinensis (L.) DC. 943
Iris pumila L. 4532

Orchidaceae

Aplectrum hyemale (Muhl.) Torr. 954
Corallorrhiza wistefiana Conrad 961
Orchis spectabilis L. 985, 987, 990

Juglandaceae

Carya ovata (Mill.) Koch. 1053, 1054
Juglans nigra L. 1064

Fagaceae

Quercus imbricaria Michx. 1098, 1099
Quercus muhlenbergii Engelm. 1102, 1103
Quercus velutina Lam. 1111, 1112

Urticaceae

Cannibis sativa L. 4387
Celtis occidentalis L. 4463
Maclura pomifera (Raf.) Schneider 4488
Morus rubra L. 1127
Ulmus americana L. 4583
Ulmus fulva Michx. 4464
Urtica gracilis Ait. 1145

Aristolochiaceae

Asarum canadense L. 1156, 1158

Polygonaceae

Fagopyrum esculentum Moench. 4462
Polygonum acre HBK 1164
Polygonum aviculare L. 1179
Polygonum careyi Olney 1186
Polygonum dumetorum L. 4388
Polygonum erectum L. 4389
Polygonum hydropiper L. 1204
Polygonum longistylum Small 4390
Polygonum maritimum L. 1205
Polygonum pennsylvanicum L. 1209
Polygonum scandens L. 1216
Polygonum virginianum L. 1217, 1220
Rumex acetosella L. 4457
Rumex altissimus Wood. 4458
Rumex conglomeratus Murr. 4459
Rumex crispus L. 4460
Rumex obtusifolius L. 1228, 1229, 1231

Chenopodiaceae

Chenopodium album L. 4391
Chenopodium ambrosioides L. 4392
Chenopodium hybridum L. 1275
Chenopodium leptophyllum Nutt. 4393
Kochia scoparia (L.) Schrad. 1280

Amaranthaceae

Amaranthus blitoides Wats. 1299
Amaranthus hybridus L. 4394
Amaranthus retroflexus L. 1308

Phytolaccaceae

Phytolacca decandra L. 1321

Nyctaginaceae

Oxybaphus nyctagineus (Michx.) Sweet 1321

Caryophyllaceae

Agrostema githago L. 1341
Cerastium brachypodium E. Robinson 4533
Cerastium vulgatum L. 4465
Lychnis alba Mill. 4466
Saponaria officinalis L. 1374
Stellaria media (L.) Cyrill 1412

Portulacaceae

Claytonia virginica L. 1419
Portulacca oleracea L. 4522

Ranunculaceae

Anemonella thalictroides (L.) Spach. 1466
Aquilegia canadensis L. 1473
Delphinium ajacis L. 4468
Myosorus minimus L. 4534
Ranunculus abortivus L. 1514
Ranunculus micranthus Nutt. 1539
Ranunculus sceleratus L. 4467
Ranunculus septentrionalis Poir. 1554

Magnoliaceae

Liriodendron tulipifera L. 1563
Magnolia grandiflora L. 4535

Calycanthaceae

Calycanthus floridus L. 1567, 4536

Anonaceae

Asimina triloba Dunal. 1568

Menispermaceae

Menispermum canadense L. 4447

Berberidaceae

Podophyllum peltatum L. 1589

Papaveraceae

Sanguinaria canadensis L. 4537

Fumariaceae

Corydalis aurea Willd. 1613, 1614
Dicentra cucullaria (L.) Bernh. 1624
Dicentra spectabilis (Ker.) Torr. 4538

Cruciferae

Arabis patens Sulliv. 1639
Brassica arvensis (L.) Ktze. 1657
Brassica campestris L. 4539
Brassica nigra (L.) Koch. 1661
Brassica rapa L. 1663
Camelina microcarpa Andrz. 1666
Camelina sativa (L.) Crantz 1667
Capsella bursa-pastoris (L.) Medic. 1674
Cardamine pennsylvanica Muhl. 4540
Conringia orientalis (L.) Dumort. 1670, 1671
Dentaria laciniata Muhl. 4541
Erysimum asperum DC. 1705
Erysimum cheiranthoides L. 4542
Lepidium apetalum Willd. 1713, 1718
Lepidium perfoliatum L. 4472
Lepidium virginicum L. 1715
Lesquerella gracilis (Hook.) Wats. 1723
Radicula obtusa (Nutt.) Greene 4471
Radicula nasturtium aquaticum (L.) Britten & Rendle 4470
Sisymbrium canescens Nutt. 1747, 1750
Sisymbrium irio L. 1752
Sisymbrium officinale L. 1709
Thlaspi arvense L. 1758

Capparidaceae

Cleome spinosa L. 1765

Saxifragaceae

Heuchera hirsuticaulis (Wheelock) Rydb. 1801
Ribes aureum Pursh. 4543
Ribes garcile Michx. 4544

Platanaceae

Platanus occidentalis L. 4489

Rosaceae

Crataegus crus-galli L. 4546
Crataegus mollis (T. & G.) Scheele 1867
Crataegus pratensis Sarg. 1866
Fragaria americana (Porter) Britton 4547
Fragaria virginiana Duchesne 4397, 4548
Geum canadense Jacq. 4398
Geum vernum (Raf.) T. & G. 1896, 1897
Kerria japonica DC. 1902
Potentilla canadensis L. 4473
Potentilla canadensis var. simplex (Michx.) T. & G. 1919
Prunus arnoldiana Rehd. 4549
Prunus persica Sieb. & Luce 4550
Prunus serotina Ehrh. 1954. 1956
Prunus triloba Lindl. 4551
Pyrus angustifolia Ait. 4552
Pyrus ioensis (Wood) Bailey 1974
Pyrus japonica Thunb. 4553
Rosa setigera Michx. 1984, 1985
Sorbaria sorbifolia (L.) A.Br. 4475
Spirea bumalda Burvenich (var. Anthony Waterer) 4478
Spirea japonica L. 2018
Spirea thunbergii Sieb. 4476
Spirea vanhouttei Zabel 4477

Leguminosae

Baptisia bracteata (Muhl.) Ell. 4554
Cassia sagittalis L. 2081
Cercis canadensis L. 4545
Desmodium canadense (L.) DC. 2172
Lotus corniculatus L. 2153
Medicago lupulina L. 2167
Melilotus alba Desr. 2177
Melilotus officinalis (L.) Lam. 4480
Robinia pseudo-acacia L. 2214
Strophostyles pauciflora (Benth.) Wats. 2222
Strophostyles umbellata (Muhl.) Britton 2224
Trifolium pratense L. 2234
Trifolium procumbens L. 2239
Trifolium repens L. 4479
Vicia dasycarpa Ten. 4481
Vicia villosa Roth. 2262

Linaceae

Linum usitatissimum L. 2274

Oxalidaceae

Oxalis corniculata L. 4399
Oxalis stricta L. 2286
Oxalis violacea L. 4555

Geraniaceae

Geranium carolinianum L. 2293
Geranium maculatum L. 2296

Zygophyllaceae

Tribulus terrestris L. 2304

Simarubaceae

Ailanthus altissima (Mill.) Swingle 4490

Euphorbiaceae

Acalypha virginica L. 4400
Crotonopsis linearis Michx. 4401
Euphorbia cyparissias L. 4556
Euphorbia dentata Michx. 2354
Euphorbia maculata L. 2361, 2368
Euphorbia marginata Pursh. 4402
Euphorbia preslii Guss. 2375, 2376

Anacardiaceae

Rhus cotinoides Nutt. 2387
Rhus typhina L. 4491

Celastraceae

Celastrus scandens L. 2405
Euonymus atropurpureus Jacq. 2415
Euonymus europaeus L. 2417

Staphyleaceae

Staphylea trifolia L. 2418, 2419, 2420

Aceraceae

Acer negundo L. 4487
Acer saccharinum L. 2442, 2444
Acer saccharum Marsh. 4486

Sapindaceae

Aesculus glabra Willd. 4557

Tiliaceae

Tilia americana L. 4492

Malvaceae

Abutilon theophrasti Medic. 2492
Callirhoe alcaeoides (Michx.) Gray 2499
Callirhoe involucrata (T. & G.) Gray 4493
Hibiscus syriacus L. 2510, 2511
Hibiscus trionum L. 4403
Malva rotundifolia L. 2520
Malva verticillata L. 2536
Sida spinosa L. 2539

Hypericaceae

Hypericum perforatum L. 2557, 2558
Hypericum pseudomaculatum Bush. 2563

Tamaricaceae

Tamarix gallica L. 4495

Violaceae

Hybanthus concolor (Forster) Spreng. 2581
Viola affinis Le Conte 4558

Viola cucullata Ait. 4559
Viola missouriensis Greene 4496
Viola papilionacea Pursh. 4561
Viola pedatifida G. Don. 4562
Viola pubescens Ait. 2609
Viola rafinesquii Greene 2614
Viola scabriuscula Schwein. 4560
Viola sororia Willd. 4563
Viola tricolor L. 4564
Viola triloba Schwein. 4565

Passifloraceae

Passiflora incarnata L. 2635

Onagraceae

Gaura parviflora Dougl. 4404

Umbelliferae

Chaerophyllum procumbens (L.) Crantz. 2738
Chaerophyllum tainturieri Hook 2739
Chaerophyllum texanum Coult. & Rose 4497
Conium maculatum L. 4499
Daucus carota L. 2753
Eryngium yuccifolium Michx. 2758
Osmorhiza claytoni (Michx.) Clarke 2775, 2777
Pastinaca sativa L. 4498
Sanicula canadensis L. 2795
Sanicula gregaria Bicknell 2799
Sanicula marilandica L. 2800
Torilis anthriscus (L.) Bernh. 2811

Cornaceae

Cornus florida L. 4566

Primulaceae

Steironema ciliatum (L.) Raf. 2916

Oleaceae

Chionanthus virginica L. 2934, 2935
Forsythia suspensa Dahl. 2936
Forsythia viridissima Lindl. 2937
Fraxinus americana L. 4500
Ligustrum vulgare L. 4501
Syringa persica L. 4567
Syringa vulgaris L. 4568

Gentianaceae

Sabatia angularis (L.) Pursh. 4502
Sabatia campestris Nutt. 2978

Apocynaceae

Amsonia tabernaemontana Walt. 2982
Apocynum androsaemifolium L. 4405
Apocynum cannabinum L. 2984
Vinca minor L. 2991

Asclepiadaceae

Asclepias incarnata L. 3003
Asclepias syriaca L. 3020
Gonolobus laevis Michx. 3037

Convolvulaceae

Convolvulus arvensis L. 4503
Cuscuta arvensis Beyrich 3052, 3053
Ipomoea hederacea Jacq. 4504
Ipomoea purpurea (L.) Roth. 4406

Polemoniaceae

Phlox divaricata L. 4569
Phlox subulata L. 4570, 4571
Polemonium reptans L. 4572

Hydrophyllaceae

Ellisia nyctelea L. 3087
Hydrophyllum appendiculatum Michx. 3092
Hydrophyllum canadense L. 4573

Boraginaceae

Cynoglossum virginianum L. 4505
Lithospermum angustifolium Michx. 4575
Lithospermum arvense L. 3118, 3120
Lithospermum gmelini (Michx.) Hitchc. 4574
Mertensia virginica (L.) Link. 4576

Verbenaceae

Phyla lanceolata Michx. 3138, 3143
Verbena bracteosa Michx. 3151
Verbena canadensis (L.) Britton 3155
Verbena stricta Vent. 3160
Verbena urticaefolia 3161

Labiatae

Lamium amplexicaule L. 4508
Lycopus uniflorus Michx. 4407
Lycopus virginicus L. 4408
Marrubium vulgare L. 4409
Monardia fistulosa L. 4507
Nepeta cataria L. 4410
Nepeta hederacea (L.) Travisan 4577
Prunella vulgaris L. 4411
Scutellaria serrata Andr. 4412
Teucrium canadense L. 4509

Solanaceae

Chamaesaracha sordida (Dunal.) Gray 3167
Datura stramonium L. 3171
Lycium halimifolium Mill. 3173
Petunia axillaris BSP 4510
Petunia violaceae Lindl. 4511
Physalis heterophylla Nees. 4413
Physalis ixocarpa Brotero 4414
Physalis lanceolata Michx. 4415
Physalis longifolia Nutt. 4416
Physalis pruinosa L. 4417
Physalis subglabrata McKenzie & Bush 3190, 3191
Solanum carolinense L. 3197
Solanum elaeagnifolium Cav. 3207
Solanum nigrum L. 3213
Solanum rostratum Dunal. 3218

Scrophulariaceae

Linaria vulgaris Hill. 3281
Mimulus alatus Ait. 3289, 3290
Pedicularis canadensis L. 3297
Verbascum thapsus L. 3337
Veronica arvensis L. 3225, 4512, 4578
Veronica peregrina L. 3232, 3239

Orobanchaceae

Orobanche uniflora L. 3354

Bignoniaceae

Catalpa speciosa Warder 3356
Tecoma radicans (L.) Juss. 3363

Acanthaceae

Ruellia ciliosa Pursh. 3369, 3373, 4419
Ruellia strepens L. 3372

Plantaginaceae

Plantago lanceolata L. 3387, 3388
Plantago rugelii Dcne. 3396
Plantago virginica L. 3397, 3398

Rubiaceae

Galium aparine L. 3412
Galium circaezans Michx. 3429
Galium concinnum T. & G. 3423, 3424
Houstonia minima Beck. 3457

Caprifoliaceae

Diervilla japonica DC. 3465
Lonicera japonica Thunb. 3477
Lonicera prolifera (Kirch.) Rehd. 3484
Lonicera tatarica L. 4517
Sambucus canadensis L. 3496
Symphoricarpos orbiculatus Moench. 4514
Viburnum lentago L. 3520
Viburnum prunifolium L. 3527, 3528, 3529

Dipsacaceae

Dipsacus sylvestris Huds. 3537

Cucurbitaceae

Sicyos angulatus L. 3547

Campanulaceae

Campanula americana L. 3557
Specularia perfoliata (L.) A.DC. 3576

Lobeliaceae

Lobelia inflata L. 3584
Lobelia siphilitica L. 3593

Compositae

Achillea millefolium L. 3606
Actinomeris alternifolia (L.) DC. 3608
Ambrosia artemisiifolia L. 3614
Ambrosia bidentata Michx. 4420
Ambrosia trifida L. 3623
Amphiachyris dracunculoides (DC.) Nutt. 3628
Antennaria neglecta Greene 4579, 4580
Antennaria plantaginifolia (L.) Richards 3634
Anthemis cotula L. 3641, 3642
Arctium minus Bernh. 3649
Aster azureus Lindl. 4448
Aster lateriflorus (L.) Britton 4449
Aster multiflorus Ait. 4450
Aster novae-angliae L. 3696, 3697
Aster salicifolius Ait. 3709, 3710
Bidens aristosa (Michx.) Britton 4421
Bidens bipinnata L. 3725, 3726
Bidens comosa (Gray) Wiegand 4422
Bidens involucrata (Nutt.) Britton 3740, 3741
Bidens vulgata Green 4423
Bidens vulgata var. puberula (Wiegand) Greene 3749
Cacalia atriplicifolia L. 3758
Centaurea cyanus L. 3766
Chrysanthemum parthenium (L.) Bernh. 3776
Chrysanthemum leucanthemum L. 4518
Cichorium intybus L. 4424
Cirsium altissimum (L.) Spreng. 4425
Cirsium discolor (Muhl.) Spreng. 4426
Cirsium lanceolatum (L.) Hill 3799
Dyssodia papposa (Vent.) Hitchc. 3810
Erigeron annuus (L.) Pers. 4427
Erigeron canadensis L. 3828
Erigeron divaricatus Michx. 3831
Erigeron philadelphicus L. 3835, 3836
Eupatrium purpureum L. 4428
Eupatrium urticaefolium var. villicaule Fernald 3862
Helianthus grosseserratus Martens 4430
Helianthus hirsutus Raf. 3894
Helianthus scaberrimus Ell. 4431
Helianthus tuberosus L. 4432
Kuhnia eupatorioides L. 3936
Lactuca canadensis L. 4429
Lactuca scariola L. 3950
Lepachys columnaris (Sims.) T. & G. 3958
Lepachys pinnata (Vent.) T. & G. 3963
Pyrrhopappus carolinianus (Walt.) DC. 3984, 3985
Rudbeckia triloba L. 4001, 4002
Senecio glabellus Poir. 4007
Silphium laciniatum L. 4019, 4026
Silphium perfoliatum L. 4519
Solidago altissima L. 4433
Solidago caesia L. 4036
Solidago serotina Ait. 4078
Solidago speciosa Nutt. 4088
Sonchus oleraceus L. 4520
Taraxicum erythrospermum Andrz. 4581
Taraxicum officinale Weber 4582
Tragopogon porrifolius L. 4521
Trogapogon pratensis L. 4522
Vernonia altissima Nutt. 4100, 4102
Xanthium commune Britton 4435

Kansas Plants New to Kansas Herbaria II

W. H. HORR and R. L. McGREGOR
University of Kansas, Lawrence.

Since writing the first of this series of papers*, we have found *Senecio glabellus* Poir. in Douglas, Leavenworth and Atchison counties.

Botrychium obliquum Muhl., which was erroneously reported as *B. dissectum* Spreng., has been found in two different places in Douglas County, and a number of additional specimens were found in Miami County near the place where they were originally collected.

Ophioglossum engelmanni Prantl. The first specimen of this plant was found April 18, 1946, growing on a rocky roadside bank 6 miles northwest of Lawrence, Douglas County. Specimens were later found in Cherokee County, 5 miles east of Baxter Springs, April 21, 1946; in Atchison County, 4 miles north of Kickapoo, June 2, 1946; on the Military Reservation in Leavenworth County, June 2, 1946; and in Miami County, on the Hugh Whiteford ranch, May 10, 1947. This plant had previously been collected from Wilson County, Kansas, in 1922, by E. J. Palmer.

Phegopteris hexagonoptera (Michx.) Fee. A large colony of this plant was found on a rocky hillside 5 miles east of Baxter Springs, Cherokee County, July 10, 1946. Britton and Brown (Illustrated Flora of the Northern United States, Canada and the British Possessions) included Kansas in plotting the range of this plant.

Filix bulbifera (L.) Underw. Several specimens of this plant were found July 7, 1946, 4 miles west of Neodesha, Wilson County. It was growing on shaded limestone rocks. It was found July 8, 1946, on limestone rocks in Chautauqua and Montgomery Counties.

Cheilanthes lanosa (Michx.) Wats. On July 10, 1930, this plant was found growing on rocks in a creek valley in Woodson County. Rydberg (Flora of the Prairies and Plains of Central North America) included Kansas in the range of this plant.

Cuscuta indecora Choisy var. *longisepala* Yuncker. Collected August 17, 1946, 3 miles southeast of Lawrence, Douglas County. A large number of these parasitic plants were found growing on *Iva ciliata* Willd.

Stellaria longifolia Muhl. This plant was first found August,

Transactions Kansas Academy of Science, Vol. 50, No. 2, 1947.

*University of Kansas Science Bulletin, vol. 31, part 1, pp. 183-184, May, 1946.

1945, growing in a yard in Lawrence, Douglas County, by Prof. W. C. Stevens. It was later collected in waste ground north of Corbin Hall, Lawrence, Douglas County, September 10, 1946.

Sparganium americanum Nutt. Collected June 23, 1946, at the north end of Baldwin City Lake, Douglas County. A large colony of this plant was found on a muddy bank at the upper end of the lake.

Centaurea maculosa Lam. A large colony of this plant was found July 13, 1940, growing in an overgrazed pasture 5 miles west of Corning, Nemaha County. Rydberg (Flora of the Prairies and Plains of Central North America) includes Kansas in plotting the range of this species.

Orobanche fasciculata Nutt. This plant was found April 20, 1946, 2 miles east of Riverton, Cherokee County, growing on a rocky hillside. It was present in considerable numbers. This plant has been reported by other collectors in an area extending from Sask.—Ind.—N. M.—Calif.—Yukon; Mex.

Triosteum angustifolium L. Collected April 20, 1946, 5 miles east of Baxter Springs, Cherokee County. A few specimens were found on rocky banks of a ravine. This collection extends the distribution farther west than any previous collection in the plains states.

Atropine Sulfate and the Retention of Fowl Ascarids[1]

J. E. ACKERT and D. J. AMEEL
Kansas State College, Manhattan.

Studies in our laboratory on the resistance of fowls to their ascarid parasites showed that certain vitamins, especially vitamins A, B complex and D, are of importance in protecting fowls from their ascarid worms. We are now in the midst of studies on the importance of protein supplements to basal cereal rations as factors in the resistance of chickens to their ascarids. In young chickens parasitized at the age of a month or so, a supplement of skim milk given on alternate days to parasitized chickens aided them in eliminating most of their worms, whereas the chickens on the same ration except for the milk retained a much larger number of their ascarids.

When comparisons were sought between groups of chickens parasitized when they were two or three months of age, difficulty was experienced in finding enough worms at autopsy to make valid comparisons between the milk fed and the control fowls. Often only a single worm was found and many of the birds in the experimental and the control groups had eliminated all of their worms at the end of a three week period. We were desirous of learning whether a high protein supplement to a basal cereal ration produced stronger resistance to the worms than did a lower protein supplement. Also we wished to know whether proteins from animal and plant sources produced more resistant fowls than supplements wholly of plant origin. But the increased natural resistance of these two- to three-month old chickens enabled too many of the fowls to eliminate most of their worms and thus prevented us from making statistical comparisons.

While attending the A.A.A.S. meetings at St. Louis, Missouri, in March, 1946, we learned from Larsh[2] that injections of morphine sulfate resulted in the retention in mice of increased numbers of tapeworms, and determined to try such an experiment with our chickens. Instead of morphine sulfate, we chose atropine sulfate, which is used as a peristaltic retardent by our local surgeons before major operations involving the intestines.

Transactions Kansas Academy of Science, Vol. 50, No. 2, 1947.

[1]Contribution No. 249 from the Department of Zoology, Agricultural Experiment Station, Kansas State College of Agriculture and Applied Science, Manhattan, Kansas.

[2]Larsh, John E., Jr., 1945. The relationship in mice of intestinal emptying time and natural resistance to Hymenolepis. Jour. Parasitol., Vol. 31 (Supplement), p. 19.

Our chickens were fed about 300 fowl ascarid eggs. Members of one group were given intra-peritoneal injections of 1/100 grain of atropine sulphate two hours after ingestion of the eggs. This retards peristalsis for at least 12 hours, allowing more time for the larvae to hatch and find their way to the preferred habitat in the posterior duodenum. An equal number of control chickens of the same age were similarly parasitized but not injected with the atropine sulfate.

At the end of three weeks the experiment was terminated, and the worms collected and counted. In the first test made from chickens 47 days old, the injected group had an average of 12.6 worms and the control an average of 9.2. This indicated that the injection of atropine sulfate had aided in the retention of *Ascaridia.*

In the second test on chickens 80 days of age, the injected fowls had an average of 4.4 worms and the controls an average of 1.4 worms. A third experiment with chickens 53 days of age showed an average of 10.3 worms in the chickens injected with atropine sulfate as compared with an average of 5.4 in the controls. In the combined results to date the injected chickens have had an average of 9.4 worms and the uninjected controls an average of 5.85 worms. A fourth test is now in progress.

The results obtained to date give some promise that atropine injected fowls will retain enough ascarid worms to make possible comparative tests which may show to what extent protein supplements are of importance in maintaining high resistance of fowls to their ascarid parasites.

Twelve Tests That Have Proved Practical in Commercial Applications

BENTLEY BARNABAS
Associated Personnel Technicians, Wichita.

It is the shared experience of many workers in the field of psychometrics that broadens and enhances the value of such scientific techniques. This brief writing represents an effort to share some six years of experience with the tests mentioned herein. It reflects the confidence of several workers in the field of industrial and commercial testing where the end-goal of the testing was the selection, placement, upgrading or training of employees. It is not suggested that other workers accept without question the experience described here. Rather, it is felt that the reader may devote effort to further validation with the knowledge that his effort is less likely to be wasted because of this experience of others.

The paper includes no comment about the many tests that have been tried and which did not prove practical economically or from the point of view of validity. To condemn a test because it failed in one or a few situations is as unscientific as to over-estimate its value. We do not have a universal common denominator for test evaluation because each situation in which tests are used requires a compromise and the compromise itself is often more important than the basic nature of the instrument or instruments used. In small groups we must compromise between rigid statistical appraisal and obvious case analysis, in industry we must compromise between extreme accuracy and the practical element of costs, in guidance we must compromise between the coefficient of correlation and the coefficient of alienation thus keeping before ourselves the fact that we are dealing with the laws of chance rather than with immutable facts.

The situations in which these tests came through to prove practical were of an extremely varied nature. They include testing for the selection of factory leaders, factory workmen in over thirty different types of work, commercial artists, salesmen, field men for distributors, office workers of several types, design engineering personnel, repair men, general "help" including household workers and other miscellaneous types of employment.

Where samples were large enough to justify statistical analysis, the tests mentioned here always established some quantitative value in validity. In those instances where the criterion groups used to

establish validity were suited to the calculation of product-moment coefficients of validity, such coefficients were calculated and the tests given weight according to the value of these knowns. In other instances, where it was difficult or impossible to obtain a quantitative scale in the criterion groups, validity was obtained purely on a "differential" basis. This "differential" validity was obtained by comparing the group used as a sample to a larger group representative of the population to see if natural forces in business had selected a group that was significantly different and homogeneously different from the larger universe. It was assumed that where the differences were great enough and the nature of the trait or traits measured was logically related to the task, validity was established at least in a tentative way. Finally, there were situations in which pure "face" validity, backed by the experience with the instrument in other situations, was used to venture a prediction.

It may be said here that experience proved three things: (1) The quantitative coefficients of validity always did a better job of prediction than would have been expected from the published estimates of their value as calculated by statistical scientists; (2) In the groups where the "differential" method was employed the batteries of tests were necessarily larger, but performed a highly accurate task in prediction where it was possible to employ large selection ratios (from three to twenty persons tested for every one selected); (3) Even "face" validity surprised those who would have expected the predictions made from the combination of test scores and common sense to have proved highly inaccurate. Here the use of large batteries, careful analysis of the tasks and effort to produce very large selection ratios gave results that were astounding in some instances. The tests predicted the behavior that the previous experience and standardization data indicated they would.

No battery in use in the experience described (which includes over 10,000 cases) contained less than 3 separate tests of those shown in the list. The average test battery included 5 of the tests mentioned hereinafter. No single battery included more than 9 tests, except a few instances in which guidance or counselling was the ultimate goal. It is significant, however, to note that the tests mentioned represent the combination of more than 80 different scales into 12 tests and that even if the many scales of the Strong Vocational Interest Blank are eliminated, there are still over 30 aspects of the subject being measured!

The twelve tests and a few comments as to any special methods

used in administering or scoring them follow. The authors and publishers are omitted since such data may be obtained quite readily from catalogues of Psychological Corporation, Science Research Associates, California Test Bureau or Stanford University Press.

The Personnel Test. This 12-minute test of mental efficiency was included in most test batteries. The four equivalent forms made it ideally suited to retesting or lengthening of the items by doubling (giving two forms at one administration).

The Otis Self-Administering Test of Mental Ability. This was used only where time limits were not important and the author's time-correction table was used for the obtaining of the raw score. Subjects were given all the time needed to complete the test.

The Tiffin-Lawshe Adaptability Test. This was used for general mental efficiency in much the same type of situation as The Personnel Test.

The Wide Range Vocabulary Test. This was used in all batteries where the selection involved picking individuals for work where verbal facility was needed. Both forms B and C are in use.

The Mechanical Comprehension Test. Form AA was used, but special norms based on more than 1,000 men were set up on a fifteen-minute time limit form of administration. This was a necessary expedient because of the necessity for terminating the administration time in a group situation.

The Purdue Test for Electricians. Only used where applicants were screened for electrical work, this test was used to compare achievement levels.

The Purdue Test for Machinists and Machine Operators. Also used as a measure of achievement levels, this test proved valuable in selecting workers for tasks similar to the ones described in its title.

The MacQuarrie Test for Mechanical Performance Ability. This test proved highly valid in situations far removed from obvious applications. The first three tests measured dexterity of three types, the last four tests measured different aspects of visualization. A total score offers another comparative scale. Examples of interesting validity of the test include: Use of the last four tests to select commercial artists and design engineering personnel; use of the first three for business machine operators; use of tests four and five in the series to locate sheet metal workers.

The Minnesota Vocational Test for Clerical Workers. Highly valid for paper-and-pencil clerical workers and in situations where number or name checking was required by the task.

The Bernreuter Personality Inventory. Highly valid under special administration conditions for certain aspects of personality. Neither standard norms nor standard administration were felt to be valid for "screening" situations, although the shift in norms was systematic when the test was given twice to the same individual, once for counselling purposes and once for selection or placement.

The Minnesota Multiphasic Personality Inventory. This test proved very valuable as an aid to the selection of persons for tasks where the trends of behavior measured could affect efficiency. The group form was not used in group situations because of concern that the group form produced a different response than the box of cards. Where groups were given the test, each individual was given a separate box of cards to sort. The test's validity was unquestionably established in a number of cases in which subsequent investigation of personal history showed up behavior patterns closely linked with the type of profile shown on the test. Among the numerous examples are cases of criminal histories, disregard for the social mores, hypomanic tendency and conversion hysterias which were found to exist in fact after having appeared as profile peaks, usually into the zones above the T score of 70.

The Strong Vocational Interest Blank. The test proved highly valid in those situations in which scales for occupations were closely linked to the task being studied. In a few cases scales of the test linked themselves quantitatively to occupations somewhat removed (from a common sense point of view) from the task under consideration. Group scales proved most valid in some situations, single occupation scales in others. Occupational Level and Interest Maturity scales also established validity in some situations.

Appraisal of the foregoing information must include a recognition of the fact that in the use of seven of the twelve tests norms other than the "standard" or author's norms were developed. In some of the tests as many as a dozen different sets of norms are employed in interpreting the test in actual practice. Those who make use of the tests will find it worthwhile to collect data for situations in which the tests are to be used and use such data to make their own predictions.

Structure of Kaolin and Related Minerals

ALFRED T. PERKINS*
Kansas State College, Manhattan.

What is kaolin? Kaolin is an important soil mineral, closely related to other minerals and having definite chemical composition and structure. Chemically, kaolin is a hydrated aluminum silicate with the accepted empirical formula of $Al_2Si_2O_5(OH)_4$. This is essentially a salt of the $H_2Si_2O_5$ silicic acid known as the meso disilicic acid with $Al(OH)_2$ radicals replacing the hydrogen atoms. For comparison with other minerals the above formula is doubled, giving $Al_4Si_4O_{10}(OH)_8$ the para tetrasilicic acid. Kaolin is composed of two highly amphoteric elements, quadrivalent silicon and trivalent aluminium, plus oxygen and hydrogen. In order to obtain a better understanding of kaolin and related minerals we reproduce an outline in Figure I of the various silicic acids as given by Mellor[5] and other authors.

FIG. I.—The Silicic Acids.

Type	*mono*	*di*	*tri*	*tetra*	*penta*	*hexa*
ortho	H_4SiO_4	$H_6Si_2O_7$	$H_8Si_3O_{10}$	$H_{10}Si_4O_{13}$	$H_{12}Si_5O_{16}$	$H_{14}Si_6O_{19}$
meta	H_2SiO_3	$H_4Si_2O_6$	$H_6Si_3O_9$	$H_8Si_4O_{12}$	$H_{10}Si_5O_{15}$	$H_{12}Si_6O_{18}$
meso		$H_2Si_2O_5$	$H_4Si_3O_8$	$H_6Si_4O_{11}$	$H_8Si_5O_{14}$	$H_{10}Si_6O_{17}$
para			$H_2Si_3O_7$	$H_4Si_4O_{10}$	$H_6Si_5O_{13}$	$H_8Si_6O_{16}$
tetero				$H_2Si_4O_9$	$H_4Si_5O_{12}$	$H_6Si_6O_{15}$
pentero					$H_2Si_5O_{11}$	$H_4Si_6O_{14}$
hexero						$H_2Si_6O_{13}$

It should be noted that the silicic acid at the bottom of each column is obtained by adding an SiO_2 group to the acid at the bottom of the column immediately to the left. It is also seen that starting from the bottom of each column the acid immediately above is obtained by adding an H_2O group. When the salts of these acids are formed by subsituting an atom such as sodium for each hydrogen atom the alkalinity of salt is greater than the alkalinity of the acid immediately below it. The ratio of base to silicon also increases as we cross the table to the left. It is therefore manifest that the alkalinity of the sodium salts of these silicic acids would increase from the bottom to the top of the table and from the right to the left.

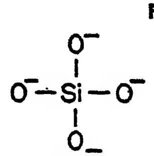
There are some advantages, as will be seen later when we compare kaolin with montmorillonite and mica, in considering kaolin as silicon aluminate rather than as the aluminum silicate. From this viewpoint kaolin is the monosilicon aluminate. The theoretical

Transactions Kansas Academy of Science, Vol. 50, No. 2, 1947.
*Contribution No. 330, Chemistry Department, Kansas Agricultural Experiment Station.

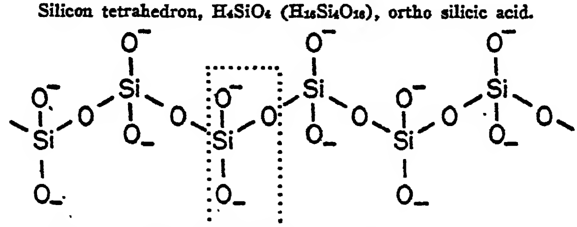
aluminates are the trihydrogen H_3O_3Al, the dihydrogen monobasic $H_2R\ O_3Al$, the monohydrogen dibasic HR_2O_3Al and the tribasic or R_3O_3Al with R representing a monovalent base. However, for the present we will consider kaolin in the conventional manner as an aluminum silicate. The structure of kaolin in its relation to other minerals is of great interest. The chemistry of the silicates in many ways is similar to that of carbon. This is understandable, as silicon comes directly under carbon in the periodic table. Studies of carbon chemistry are of great help in studying the chemistry of silicon. The simplest and most abundant silicon compound is probably silica or SiO_2. With the addition of two molecules of water this gives H_4SiO_4 or ortho monosilicic acid.

In studying the structure and characteristics of the silicic acids and the corresponding minerals, the SiO_4 radical of the H_4SiO_4 acid is of great importance. This group is considered as the SiO_4 tetra-

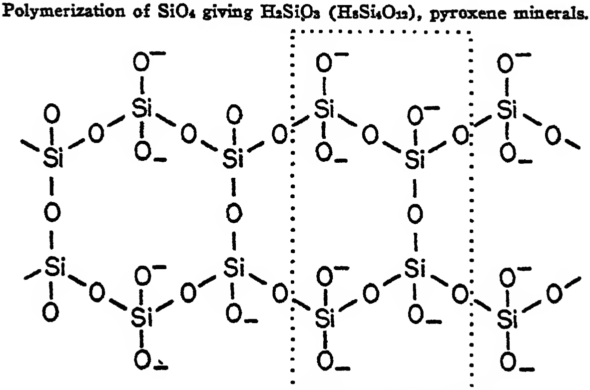
FIG. II.—Polymerization of SiO_4



Silicon tetrahedron, H_4SiO_4 ($H_{16}Si_4O_{16}$), ortho silicic acid.



Polymerization of SiO_4 giving H_2SiO_3 ($H_8Si_4O_{12}$), pyroxene minerals.



Polymerization of SiO_4 giving $H_6Si_4O_{11}$, the amphibol minerals.

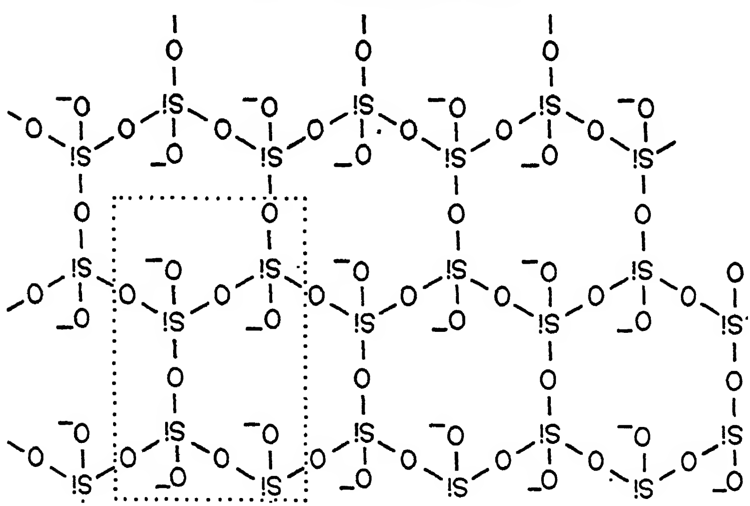
hedron. The silicic acids and salts have a strong tendency to hydrate and dehydrate passing from one acid to another. In addition to this tendency to hydrate, the SiO_4 tetrahedron will polymerize, forming chains and sheets of silicon and oxygen atoms. Hydration and polymerization are closely interrelated. Figure II shows the fundamental reactions in the first several steps of polymerization. The formation of a single chain results in the formation of the pyroxene minerals, while the double chain results in the amphibol minerals.

It should be noted that as we pass from H_4SiO_4 to $H_8Si_4O_{12}$ to $H_6Si_4O_{11}$ the ratio of H_2O to Si decreases, or that the minerals dehydrate. As polymerization continues to give kaolin, this dehydration progresses. The various pyroxene and amphibol minerals are formed by the substitution of various cations for the hydrogen atoms of the corresponding silicic acids. The pyroxene mineral enstatite is $Mg_4Si_4O_{12}$. Replacement of part of the magnesium atoms of enstatite with ferrous iron gives hyperesthene. The various amphibol minerals are formed by somewhat similar substitutions of the hydrogen atoms in $H_6Si_4O_{11}$.

The crystal structure of the pyroxene and amphibol minerals as well as all other minerals is characteristic, and these minerals may be classified by the mineralogist with little or no knowledge of their chemical composition or classification as a silicic acid.

The third step in polymerization of the SiO_4 tetrahedron in

FIG. III.—Polymerization of SiO_4

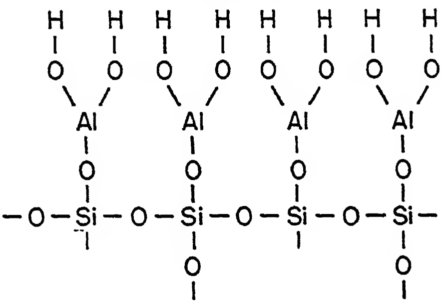


Polymerization of $SiO_4 \longrightarrow H_4Si_4O_{10}$, kaolin, etc.

forming the silicate minerals is to extend the linkage in both directions forming sheets of an unlimited number of silicon atoms in each of two directions. This gives us the $H_4Si_4O_{10}$ or the para tetrasilicic acid. This polymerization is shown in Figure III and is the basis of kaolin, montmorillonite, and allied minerals, including the micas.

In the actual composition of kaolin four hydrogen atoms of the $H_4Si_4O_{10}$ silicic acid are replaced by the monovalent $Al(OH)_2$ radical. The actual structure would be much as shown in Figure IV, it being understood that the four silicon atoms are part of a hexagon ring as shown in Figure III. The complete structure of kaolin

FIG. IV.—Polymerization of SiO_4



Lateral view of kaolin, $H_4Si_4O_{10}$ $((Al(OH)_2)_4Si_4O_{10})$

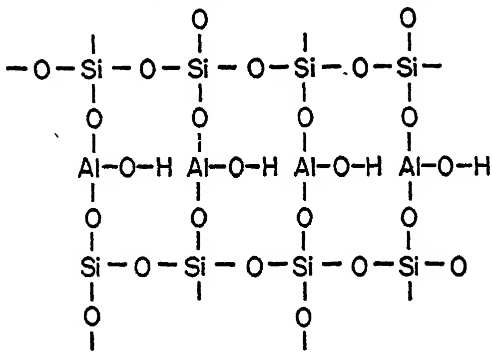
places a large number of these sheets in a pile so that the (OH) radicals are not exposed in great numbers, the exposure occurring mostly at the edges of the crystals. For a more complete description of these minerals the reader is referred to Bragg[1], Hendricks[3], Grim[2], Sedletsky[6], Marshall[4] and others.

A study of the chemical composition of the pyroxenes, amphibols, kaolin, montmorillonite and the micas shows that they may all be considered as the tetrasilicic acids, with the last three essentially being the para tetrasilicic acid.

The composition of montmorillonite as a silicic acid is the same as kaolin, both being $H_4Si_4O_{10}$. Actually these two minerals are quite different in their chemical and physical characteristics, and a chemical classification separating these two minerals is highly desirable. Each mineral contains the highly amphoteric silicon and aluminium, and both elements are multiple valent. Convention and electrovalence require that we consider these compounds as alumino silicates. As a silicate, kaolin is the aluminium dihydroxy monosilicate, while montmorillinite as shown in Figure V would be the

would be the monosilicon aluminate while montmorillonite would aluminium monohydroxy silicate. Considered as aluminates, kaolin

FIG. V.—Lateral view of montmorillonite $H_4Si_4O_{10}$ $((AlOH)_4(Si_4O_{10})_2)$



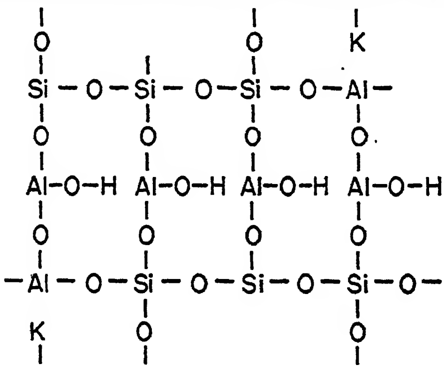
be the disilicon aluminate. The structure of montmorillonite is shown in Figure V and corresponds to the structure of kaolin as shown in Figures III and IV, it being understood that the eight silicon atoms shown in Figure V are parts of hexagon rings. A difference between kaolin and montmorillonite is that kaolin is composed of alternate silicon and aluminum sheets, while montmorillonite has two silicon sheets for each aluminum sheet.

The structure of the micas is very similar to that of montmorillonite. The chief difference from a chemical standpoint is that one of each four silicon atoms as shown in Figures III and V is replaced by a trivalent aluminum atom as structural atoms. The lost valence is accounted for by connecting a potassium atom to the oxygen linkage that formerly combined with the replaced silicon.

The aluminum atoms of the micas that do not enter into the structure of the hexagon rings but combine with these rings as shown for kaolin in Figure IV and montmorillonite in Figure V are called combined aluminums. As silicates, the micas like montmorillonite would be aluminium monohydroxy disilicates and as aluminates would be the disilicon aluminates. An acceptable chemical name for the micas would be the aluminum alumino silicates, with the structural aluminum playing the alumino role. The structure of mica is given in Figure VI, it being understood that the layer of three silicons and one aluminium forms part of a hexagon ring as shown in Figure III.

The various micas differ from each other by substituting sodium atoms for potassium atoms, by substituting three magnesium atoms

FIG. VI.—Lateral view of mica $H_4Si_4O_{10}$ $(K_2(AlOH)_4(AlSi_3O_{10})_2)$



for two combined aluminium atoms, by substitution of either ferric or ferrous iron for combined aluminum, and by similar substitutions.

The structure of the felspars is quite different from that of the preceding minerals as four instead of six silicon atoms interlocked to form rings. In the felspar as in the micas one out of each four silicon atoms is replaced by an aluminum atom. The extra free oxygen valence that would have been connected with the replaced silicon is satisfied by combining with a basic atom. The variety of the felspars depends on the individual chemical atom combining with the oxygen, as potassium giving microline or orthoclase, sodium giving albite. The felspars would fit into the series of silicic acids as the pentero-tetrasilicic acid or $(SiO_2)_4$ with one silicon replaced by an aluminum.

The minerals listed could all be placed in the tetrasilicic acid group. As we progress from the pyroxenes through the amphibols and the kaolin, montmorillonite, mica group to felspar, it is clear from the formulas in Figure I that the characteristics of the minerals must change. A pyroxene mineral has eight cation valences for each four silicon atoms, an amphibol has six cations for four silicon atoms, kaolin and similar minerals have four cation valences for four silicon atoms, and the felspars none. It is thus clear that the ability of a soil to buffer against increasing acidity can to a considerable degree be measured by the type of minerals it contains; the greater the oxygen silicon ratio, the greater is the potential alkalinity of the soil.

In addition to the greater potential alkalinity of the more highly hydrated silicates, alkalinity in the para tetra and the penetro tetrasilicate minerals is increased by the presence of an extra potassium

or sodium atom in the micas and felspars resulting from the replacement of a trivalent aluminum atom for the quadrivalent silicon atom.

The above discussion over-idealizes the structure of the aluminum silicate minerals, but it does give us a workable classification of the minerals and helps us understand the conditions essential for their formation. In studying the formation of kaolin and other minerals we must remember that both silicon and aluminum are highly amphoteric in nature. The formation of kaolin would require a balance between the soluble aluminum and silicon atoms, with approximately equal numbers of each being available. Considering kaolin as an aluminum silicate resulting from the combination of $H_4Si_4O_{10}$ and $Al(OH)_3$, the reaction of the solution must be such that the four hydrogens of $H_4Si_4O_{10}$ will ionize and one hydroxyl of $Al(OH)_3$; an alternate to this reaction, would be one that would permit the four hydroxyls of $H_4Si_4O_{10}$ and one hydrogen of $Al(OH)_3$ to ionize. This condition would probably be reached in a weakly acid reaction. In considering the formation of montmorillonite there must be twice as many silicon atoms available as there are aluminum atoms, and the reaction must be such that the four hydrogens of $H_4Si_4O_{10}$ would ionize and two hydroxyl groups of $Al(OH)_3$ would ionize. As an alternate the four hydroxyls of the $H_4Si_4O_{10}$ and two hydrogens of $Al(OH)_3$ could ionize. This alternate reaction would require a somewhat more basic reaction than the alternate suggestion for the formation of kaolin. The equations for these reactions would be:

$$H_4Si_4O_{10} + 4(HO)_3Al \rightarrow 4H_2O + (Al(OH)_2)_4Si_4O_{10}$$

$$2H_4Si_4O_{10} + 4(HO)_3Al \rightarrow 8H_2O + (AlOH)_4(Si_4O_{10})_2$$

As montmorillonite is normally found in somewhat more basic soils than is kaolin, it is probably formed in soils where the pH value is higher; the higher pH value would induce ionization such that the second reaction would result. The higher pH value also would decrease the amount of soluble aluminum, which would result in the second reaction.

The role that organic matter plays in the formation of soil minerals is beyond the scope of the present paper. Organic matter does have a considerable effect on the solubility of aluminum and is an important factor in mineral formation. The conditions under which an aluminum atom can substitute for a silicon atom in the micas and felspars are probably similar to the conditions that would result in the formation of montmorillonite instead of kaolin.

Summary

A brief outline of the classification of pyroxene, amphibol, clay, mica, and felspar minerals as chemical compounds has been given. The minerals discussed have been classified as silicates, aluminium salts, and as aluminates, and the relationship of the minerals has been shown. The pyroxenes are classified as meta tetrasilicic acid; and the felspars as pentero tetrasilicic. The micas and felspars are partially substituted silicic acids. To differentiate between kaolin and montmorillonite, kaolin has been classified as a monosilicon aluminate and montmorillonite as a disilicon aluminate.

Bibliography

(1) W. L. Bragg (1937) Atomic Structure of Minerals. Cornell Univ. Press. Ithaca, New York.

(2) Ralph E. Grim (1942) Modern Concepts of Clay Minerals. J. Geol. 50:225-75.

(3) Sterling B. Hendricks (1945) Base Exchange in Crystaline Silicates. Jour. Ind. and Eng. Chem. 37, 625-30.

(4) C. E. Marshall (1936) Trans. Ceram. Soc. 35, 401-40. Chemical Constitution as related to the Clays.

(5) J. W. Mellor (1924) A Comprehensive Treatise on Inorganic and Theoretical Chemistry. Vol. 5. Longmans & Co. London.

(6) I. D. Sedletsky (1942) Subdivision of Colloid Dispersed Minerals of the Montmorillonite Group. Compt. Rand. Acad. Sci. (U.R.S.S. 34) 130-3.

On the Curvature of Freezing Point Lines in Two Component Systems

W. J. ARGERSINGER, JR.
University of Kansas, Lawrence.

The equilibrium between liquid and solid phases in a two component system, at a constant pressure such that the vapor phase is necessarily absent, is easily described by a two dimensional phase diagram, a plot of temperature against composition. In the simplest two component systems, no compounds or solid solutions are formed between the two components, and the solid phases are always the pure solid components. Such a system is the system $CHCl_3$-C_6H_6.[1,2]

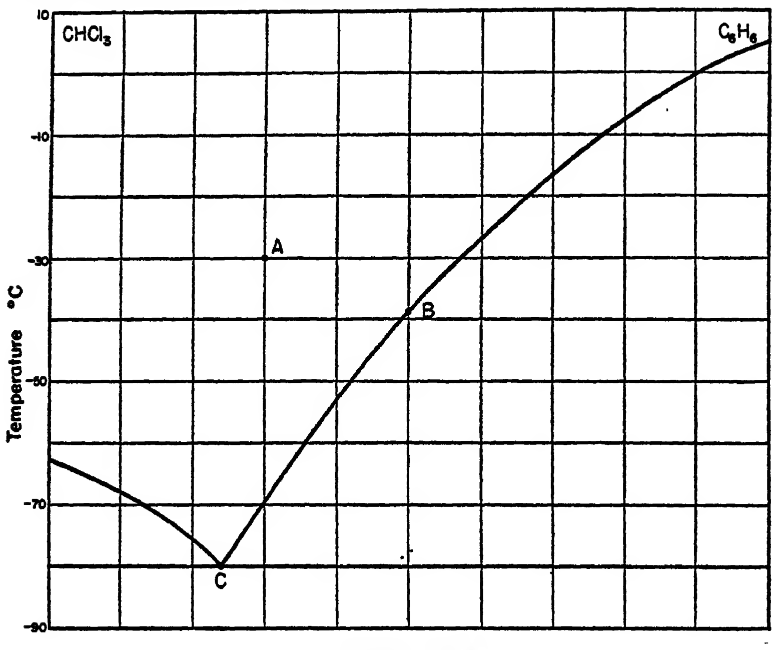


Figure 1.

The application of the phase rule to a system of this type at constant pressure shows that a single liquid phase is represented by a point, point A for example, within an area of restricted extent where the temperature and composition are independently variable. A system consisting of a liquid and a solid phase in equilibrium is represented by a point, B, on one of two lines, the freezing point

curves, along which either the temperature or composition may be varied. Finally, a system consisting of one liquid phase and two solid phases in equilibrium is represented by a single invariant point, C, the eutectic of the system at the given constant pressure.

The experimental determination, interpretation, and use of such diagrams are familiar to everyone. Possibly less familiar is the calculation of the diagrams, or more particularly, the freezing point lines, from the physical properties of the pure components, using certain thermodynamic relationships and, to be sure, assumptions or approximations which can usually be justified. The entire diagram is known when the two freezing point curves have been determined. These two curves, along which liquid and one solid phase are in equilibrium, are described by equations of form:[8]

$$T = \frac{T_M}{1 - \frac{RT_M}{L_1} \ln x} \tag{1}$$

where T is the equilibrium temperature, T_M the melting point of the pure solid component, both on the absolute scale, R the gas constant, L_1 the heat of fusion of the pure solid component, and x the mole fraction of the given component in the liquid phase. In deriving this equation the solution has been assumed ideal, and the small variation of the heat of fusion with temperature has been neglected. So long as a given system can obey these restrictive assumptions, the equations will reproduce the freezing point curves.

Since the mole fraction x of the given component is never greater than unity, the denominator in the expression for the equilibrium temperature T, or the freezing point, is never less than unity, and any addition of a second component lowers the freezing point of the first component, in agreement with common experience. The rate of this lowering is determined by the magnitude of the quantity $\frac{RT^2_M}{L}$, related to the cryoscopic constant of the given component.

The freezing point curves in these two component systems at constant pressure are generally observed to be convex upward, as in the $CHCl_3$-C_6H_6 system. However there is no a priori reason to expect this to be universal, and in fact systems are known in which at least one freezing point curve is concave upward. For systems which obey reasonably well the restrictive assumptions used to obtain the freezing point equations, it is possible to determine directly by differ-

entiation of Equation (1) the criterion for the curvature of these lines. However it is not much more difficult to obtain directly exact expressions involving no assumptions at all concerning the nature of the solution or the behavior of the quantity L_1.

Along a freezing point curve there are two phases in equilibrium, solution and solid; the solid phase may be a compound, a solid solution, or one of the pure components of the solution. Strictly speaking along freezing point curves the solid phase is the pure solid solvent, and this will be assumed here. Since the two phases are in equilibrium we have the requirement

$$\mu_1^{(1)} = \mu_1^{(s)} \tag{2}$$

where $\mu_1^{(1)} = \mu_1^{(1)}(T,p,x)$ is the chemical potential of component 1 (solvent) in the solution at temperature T, pressure p and mole fraction of component 1 (solvent) x, and $\mu_1^{(s)} = \mu_1^{(s)}(T,p)$ is the chemical potential of pure solid component 1 (solvent) at temperature T and pressure p. This requirement must be satisfied all along the curve as T and x vary. There is no analogous requirement for component 2, of course, because it is present in only the solution phase.

To determine the curvature of the equilibrium curve, it is necessary first to obtain the expression for its slope. Along the curve Equation (2) must be satisfied; it is convenient to rewrite this as

$$\mu_1^{(1)} - \mu_1^{(s)} = \text{constant} = 0 \tag{3}$$

and then to consider the differential coefficient

$$\left(\frac{\partial T}{\partial x}\right)_{p,\ \mu_1^{(1)}-\ \mu_1^{(s)}} \tag{3^1}$$

which gives the slope of the freezing point line.

By the properties of partial derivatives

$$\left(\frac{\partial T}{\partial x}\right)_{p,\ \mu_1^{(1)}-\ \mu_1^{(s)}} = -\frac{\left(\frac{\partial \mu_1^{(1)}}{\partial x}\right)_{T,p} - \left(\frac{\partial \mu_1^{(s)}}{\partial x}\right)_{T,p}}{\left(\frac{\partial \mu_1^{(1)}}{\partial T}\right)_{x,p} - \left(\frac{\partial \mu_1^{(s)}}{\partial T}\right)_{x,p}} \tag{4}$$

In this expression the second term in the numerator vanishes, because the solid phase is pure solid solvent, so that its chemical potential is a function only of the temperature and the pressure. In the denominator, from ordinary thermodynamic relationships

$$\left(\frac{\partial \mu_1^{(l)}}{\partial T}\right)_{x,p} - \left(\frac{\partial \mu_1^{(s)}}{\partial T}\right)_{x,p} = -\left(\bar{S}_1^{(l)} - \bar{S}_1^{(s)}\right) \qquad (5)$$

where $\bar{S}_1^{(l)}$ and $\bar{S}_1^{(s)}$ are the partial molal entropies of component 1 in the liquid and solid phases respectively. Since the solid phase is pure solid solvent,

$$\bar{S}_1^{(s)} = S_1^{(s)} \qquad (6)$$

where $S_1^{(s)}$ is the molal entropy of solid component 1.

Furthermore, since along the freezing point curve the liquid and solid phases are in equilibrium

$$\bar{S}_1^{(l)} - S_1^{(s)} = \frac{\bar{H}_1^{(l)} - H_1^{(s)}}{T} = \frac{\bar{L}_1}{T} \qquad (7)$$

where $\bar{H}_1^{(l)}$ is the partial molal heat content of component 1 in the liquid, $H_1^{(s)}$ is the molal heat content of component 1 in the solid and $\bar{L}_1$ is the relative partial molal heat content of component 1, or the heat absorbed when one mole of pure solid solvent dissolves in an infinite volume of the solution.

Finally, keeping in mind that the pressure is held constant and that the system is at equilibrium, it is convenient to write

$$\left(\frac{\partial T}{\partial x}\right)_{p,\ \mu_1^{(l)} - \mu_1^{(s)}} = \frac{dT}{dx} \qquad (8)$$

With these simplifications Equation (4) becomes

$$\frac{dT}{dx} = \frac{T}{\bar{L}_1}\left(\frac{\partial \mu_1^{(l)}}{\partial x}\right)_{T,p} \qquad (9)$$

In order to determine the curvature it is necessary to consider $\frac{d^2T}{dx^2}$. This may be obtained by differentiating Equation (9) with respect to x, the mole fraction of component 1. This differentiation, in which $\frac{d}{dx}$ represents as before differentiation at constant pressure and along the equilibrium line, requires the relations

$$\frac{d\bar{L}_1}{dx} = \left(\frac{\partial \bar{L}_1}{\partial x}\right)_{T,p} + \left(\frac{\partial \bar{L}_1}{\partial T}\right)_{x,p}\frac{dT}{dx} \qquad (10)$$

and

$$\frac{d}{dx}\left(\frac{\partial \mu_1^{(1)}}{\partial x}\right)_{T,p} = \left(\frac{\partial^2 \mu_1^{(1)}}{\partial x^2}\right)_{T,p} + \left(\frac{\partial^2 \mu_1^{(1)}}{\partial x \partial T}\right)_p \frac{dT}{dx} \tag{11}$$

Performing the differentiation and combining terms, one obtains finally

$$\frac{d^2T}{dx^2} = \frac{T}{\bar{L}_1}\left\{\left(\frac{\partial^2 \mu_1^{(1)}}{\partial x^2}\right)_{T,p} + \frac{1}{\bar{L}_1}\left(\frac{\partial \mu_1^{(1)}}{\partial x}\right)_{T,p}\left[\left(\frac{\partial \mu_1^{(1)}}{\partial x}\right)_{T,p}\right.\right. \tag{12}$$

$$\left.\left. + T\left(\frac{\partial^2 \mu_1^{(1)}}{\partial x \partial T}\right)_p - \left(\frac{\partial \bar{L}_1}{\partial x}\right)_{T,p} - \frac{T}{\bar{L}_1}\left(\frac{\partial \mu_1^{(1)}}{\partial x}\right)_{T,p}\left(\frac{\partial \bar{L}_1}{\partial T}\right)_{x,p}\right]\right\}$$

This exact expression allows one to predict the curvature of the freezing point line. This line will be convex upward, straight, or concave upward, according as the right member of Equation (12) is negative, zero, or positive. It is possible that the sign of the right member of Equation (12) may change at some intermediate value of the mole fraction x; in such case an inflection point will be observed in the freezing point curve.

Of course definite predictions cannot be made directly from Equation (12); in order to go further certain assumptions about the nature of the solution and the behavior of $\bar{L}_1$ must be made. The simplest assumptions are these:

1) The solution is ideal.

2) The heat of fusion of the pure solid solvent is constant over the temperature range considered.

In an ideal solution the chemical potential of component 1 may be written

$$\mu_1^{(1)} = \mu_1^{\circ}(T,p) + RT \ln x \tag{13}$$

and from this are obtained the derivatives:

$$\left(\frac{\partial \mu_1^{(1)}}{\partial x}\right)_{T,p} = \frac{RT}{x}$$

$$\left(\frac{\partial^2 \mu_1^{(1)}}{\partial x^2}\right)_{T,p} = -\frac{RT}{x^2} \tag{14}$$

$$\left(\frac{\partial^2 \mu_1^{(1)}}{\partial x \partial T}\right)_p = \frac{R}{x}$$

Furthermore in an ideal solution $\overline{L}_1 = L_1$, the molar heat of fusion of the pure solid component. This then is independent of composition, and so

$$\left(\frac{\partial \overline{L}_1}{\partial x}\right)_{T,p} = 0 \tag{15}$$

and by assumption 2,

$$\left(\frac{\partial \overline{L}_1}{\partial T}\right)_{x,p} = 0 \tag{16}$$

Substituting Equations (14), (15) and (16) in Equation (12)

$$\frac{d^2T}{dx^2} = \frac{RT^2}{L_1^2 x^2}(2RT - L_1) \tag{17}$$

Thus, for ideal solutions for which the heat of fusion of pure solvent may be regarded as constant over a temperature range, the curvature criterion is simply the relative magnitude of the heat of fusion:

If

$L_1 > 2RT$, the curve is convex upward

$L_1 = 2RT$, the curve is straight (i.e., there is an inflection point at the temperature $T_i = L_1/2R$)

$L_1 < 2RT$, the curve is concave upward.

These expressions hold for the entire length of the freezing point line; thus near $x = 1$ the curve may be concave upward, but as x decreases T decreases, and the curve may become convex upward.

The behavior near the ordinate representing the pure component may be determined by inserting the melting point temperature, T_M. For a substance whose heat of fusion L_1 is greater than 2R times its melting point on the absolute scale, or in other words, whose entropy of fusion is greater than 2R cal./deg.-mole, the curve is convex upward. Most substances exhibit this property and consequently most freezing point lines are convex upward. However, some substances have abnormally low entropies of fusion, and these should show freezing point curves which are concave upward, at least near the ordinate representing the pure component.

Probably the most common of such compounds is CCl_4. Its melting point is —22.9° C, and its heat of fusion 601 cal./mole;[4]

from these data the entropy of fusion is calculated to be 2.40 cal./deg.-mole, considerably less than 2R cal./deg.-mole. The system $CHCl_3$-CCl_4,[5,6] which obeys reasonably well the restrictive assumptions, is found experimentally to exhibit this behavior.

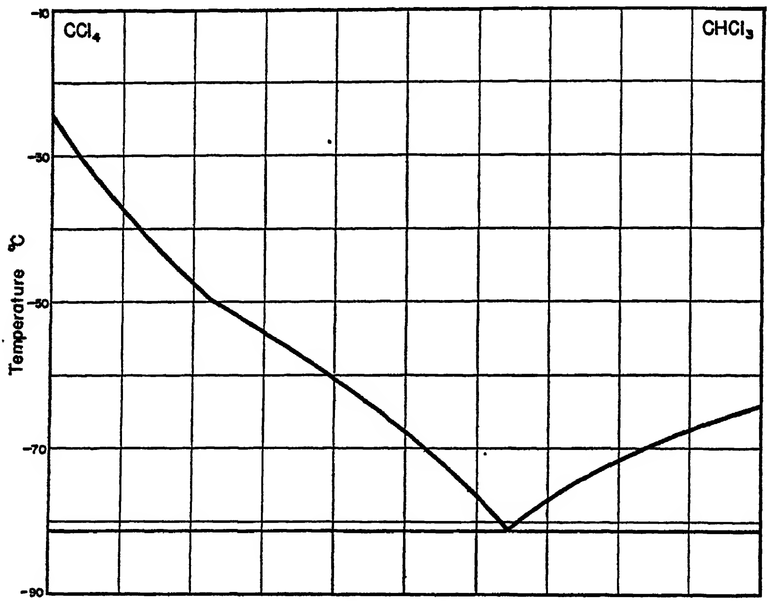


Figure 2.

In this system as the mole fraction of CCl_4 decreases, the curve becomes convex upward, illustrating the dependence of form on the changing magnitude of the quantity $\frac{L_1}{2RT}$. It is interesting to note that in spite of this and other systems involving CCl_4 as one component which show clearly the concave curves, diagrams of some other CCl_4 systems have been published with very few experimental points on the freezing point line and well rounded convex curves drawn through or around these points.

Before leaving this system it is also interesting to point out that CCl_4 undergoes a transition at —47.8° C, with a heat of transition of 1095 cal./mole.[4,7] The solid form stable at the lower temperature therefore has a heat of fusion of about 1700 cal./mole, and an estimated melting point of about —39° C. From these values the entropy of fusion of this solid form is about 7.3 cal./deg.-mole, much greater than 2R cal./deg.-mole, and the freezing point curve of

this form should be convex upward throughout. The transition is responsible for the break in the experimental curve as the temperature decreases, which partially masks the concavity of the upper branch.

Examples of greatly different compounds with abnormally low entropies of fusion are cyclohexanol, with a value of 1.4 cal./deg.-mole, and sodium hydroxide, with a value of 2.7 cal./deg.-mole. Unfortunately the freezing point data for these compounds are either very scarce or else not complete enough to show conclusively the expected behavior; the few experimental points can be fitted to curves either convex or concave upward near the ordinate representing the pure component.

Most metals have low entropies of fusion, such as cadmium 2.6, lead 2.0, aluminum 2.8, copper 2.0, tin 3.3, sodium 2.0 and gold 2.3 cal./deg.-mole. Several systems of two metals, in which no solid solutions or compounds are found, show freezing point curves which are concave upward. Among these is the system Sn-Cd,[8,9]

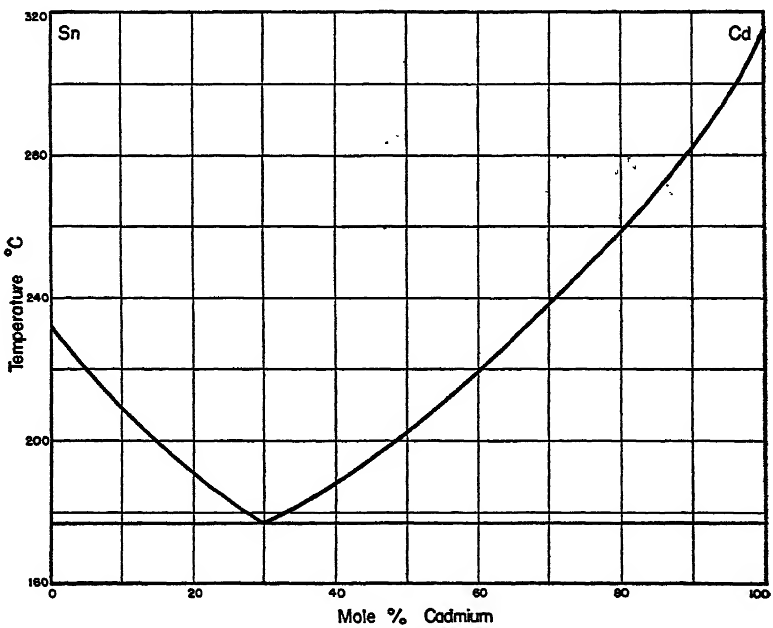


Figure 3.

It has been noted that ammonium nitrate in several systems shows freezing point curves which are concave upward;[10] the entropy of fusion of ammonium nitrate is less than 2R cal./deg.-mole.

which contains two such curves over reasonably long ranges of composition.

Finally ascorbic acid in two systems, with nicotinic acid and with nicotinamide, exhibits freezing point curves which are concave upward.[11] An indirect determination of the heat of fusion of ascorbic acid leads to an estimated entropy of fusion of about 1.2 cal./deg.-mole, considerably less than 2R cal./deg.-mole.

To summarize then, freezing point lines in two component liquid-solid equilibrium diagrams are usually convex upward, but may be concave upward at least in part for substances whose entropy of fusion is less than 2R cal./deg.-mole. Among such substances are metals which crystallize in atomic lattices, carbon tetrachloride, ammonium nitrate, and ascorbic acid. Experimental data for other substances which have low entropies of fusion, such as cyclohexanol and sodium hydroxide, are too scarce to determine the curvature of the freezing point lines, but, at least in solutions which do not depart too greatly from ideal behavior, these too may be expected to be concave upward.

Literature Cited

(1) Wroczynski and Guye, J. Chim. Phys., *8,* 189 (1910); I.C.T. IV, 99 (1928).
(2) Wyatt, Trans. Faraday Soc., *24,* 429 (1928).
(3) Schröder, Z. Phys. Chem., *11,* 449 (1893).
(4) Hicks, Hooley and Stephenson, J. Am. Chem. Soc., *66,* 1064 (1944).
(5) Kanolt, Scientific Papers, Bureau of Standards 20, No. 520, p. 619 (1926); I.C.T. IV, 98 (1928).
(6) Timmermans, Bull. Soc. Chim. Belg. *37,* 409 (1928).
(7) Latimer, J. Am. Chem. Soc. *44,* 90 (1922).
(8) Stoffel, Z. Anorg. Chem., *53,* 137 (1907); I.C.T. II, 416 (1927).
(9) Kapp, Inaugur.-Diss., Königsberg in Pr. (1901).
(10) Davidson and Geer, J. Am. Chem. Soc., *55,* 642 (1933).
(11) Bailey, Bright and Jasper, *ibid., 67,* 1184 (1945).

Some Reactions of the Polychlorides Obtained by the Chlorination of Isobutane

ROBERT W. TAFT, JR.* and GEORGE W. STRATTON
University of Kansas.

The products of the photochemical chlorination of isobutane were reported by us in another paper.[1] In order to find possible industrial uses for these products a series of dehydrochlorination experiments were carried out. These reactions were found also to be of some theoretical interest. The importance and chemical reactions of the monochlorides have been previously well established and were not investigated in the study.

Three series of dehydrochlorination reactions were carried out with the polychlorides of isobutane: (1) reactions with sodium hydroxide, or silver oxide and sodium hydroxide in water; (2) reactions with sodium hydroxide in triethanolamine; and (3) reactions with sodium hydroxide in absolute ethyl alcohol. The following equations show the reactions which take place for each of the polychlorides (see Experimental):

1,2-dichloro-2-methylpropane

(1) not run

$$(2)\quad ClCH_2-\underset{Cl}{\overset{CH_3}{C}}-CH_3+NaOH \xrightarrow[\text{triethanolamine}]{75\%} H\overset{Cl}{C}=\overset{CH_3}{C}-CH_3+NaCl+H_2O$$

$$(3)\quad ClCH_2-\underset{Cl}{\overset{CH_3}{C}}-CH_3+NaOH \xrightarrow[\text{absolute alcohol}]{56\%} H\overset{Cl}{C}=\overset{CH_3}{C}-CH_3+NaCl+H_2O$$

1,3-dichloro-2-methylpropane

(1) not run

$$(2)\quad ClH_2C-\underset{H}{\overset{CH_3}{C}}-CH_2Cl+NaOH \xrightarrow[\text{triethanolamine}]{} (ClH_2C-\overset{CH_3}{C}=\overset{H}{C}H)$$

$$\longrightarrow \text{uninvestigated amine products} + NaCl + H_2O$$

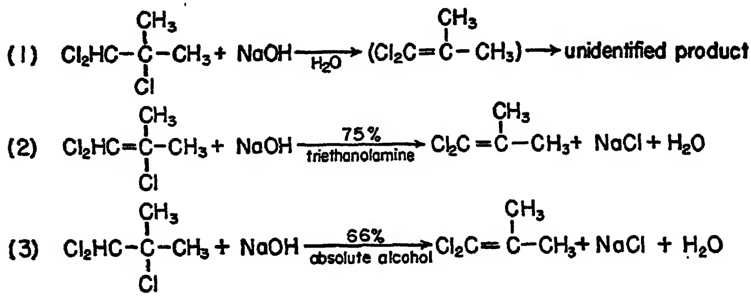
$$(3)\quad ClCH_2-\underset{H}{\overset{CH_3}{C}}-CH_2Cl+2NaOH \xrightarrow[\text{absolute alcohol}]{} ClCH_2-\overset{CH_3}{C}=\overset{H}{C}H$$

$$\xrightarrow[\text{over-all}]{47\%} H_2C=\overset{CH_3}{C}-CH_3OC_2H_5+2NaCl+2H_2O$$

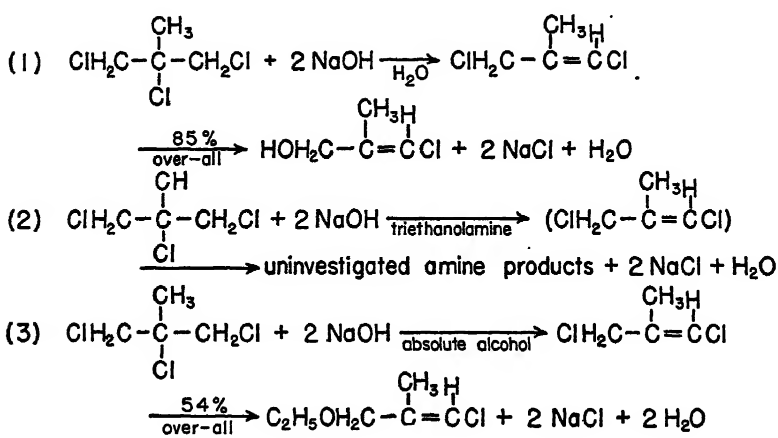
Transactions Kansas Academy of Science, Vol. 50, No. 2, 1947.

*Present address The Ohio State University, Columbus.

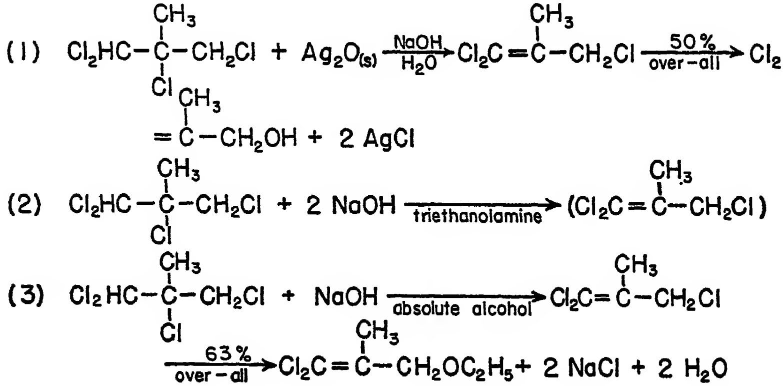
1,1,2-trichloro-2-methylpropane



1,2,3-trichloro-2-methylpropane



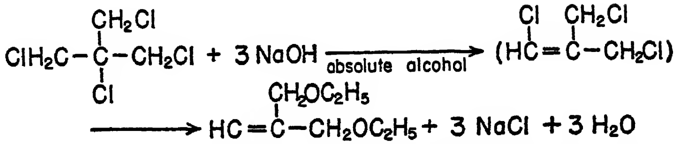
1,1,2,3-tetrachloro-2-methylpropane



1,2,3-trichloro-2-chloromethylpropane

(1) not run

(2) not run

(3) 

No reactions were run with 1,1,2,3-tetrachloro-2-chloromethylpropane, or 1,1,1,2,3-pentachloro-chloromethylpropane.

The primary reaction in every case is the removal of hydrogen chloride from the polychloride molecule. The structure of any of the saturated polychlorides is such that a molecule of hydrogen chloride could be removed in several ways, resulting in different isomers. However, previous studies of this type reported in the literature have shown that the most acid hydrogen atom in the molecule is the one removed by alkaline dehydrochlorination. Thus, with this series of compounds, the hydrogen atom removed should be the one attached to the substituted methyl group bearing the greatest number of chlorine atoms. Removal of this hydrogen atom together with the tertiary chlorine atom in every case results in a chloro-olefin whose structure agrees with that obtained in each of the reactions shown above.

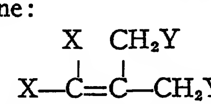
The chloro-olefins resulting from dehydrochlorination may undergo secondary metathesis reactions if allylic chlorine atoms are produced. Vinyl chlorine atoms produced by the dehydrochlorination never undergo methathesis under ordinary conditions. Accordingly, in the cases of 1,2-dichloro-2-methylpropane, and 1,1,2-trichloro-2-methylpropane, the corresponding vinyl olefinic chlorides are produced in either solvent, and no further reaction takes place.

In the cases of 1,3-dichloro-2-methylpropane, 1,2,3-trichloro-2-methylpropane, 1,1,2,3-tetrachloro-2-methylpropane, and 1,2,3-trichloro-2-chloromethylpropane, dehydrochlorination is the first step of the reaction. Secondary metathesis reactions follow (under the conditions at which the experiments were conducted) so that the resulting allylic olefinic chlorides were not isolated from the reaction. In aqueous sodium hydroxide solutions these chlorides react further to give unsaturated alcohols; in the triethanolamine solvent, they react further to give uninvestigated amine products; and in ethyl alcohol, unsaturated ethers are formed.

Although no attempt was made to isolate the allylic olefinic

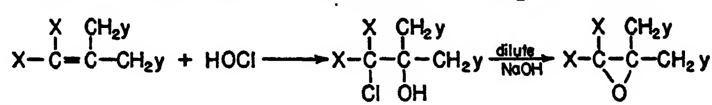
chlorides obtained by unsaturation of the above polychlorides, the secondary reaction in at least the case of one of these and in many analogous reactions has been prevented by keeping the temperature low. As an example of this, Whaley has reported that 1,1,3-trichloro-2-methylpropene-1 may be obtained in 80-90% yield by addition of a solution of sodium hydroxide in methanol to 1,1,2,3-tetrachloro-2-methylpropane with vigorous stirring maintaining the temperature at 0-10 C. in an ice bath.

The above results and those of the investigation of the metathesis reactions of β-methyl allyl chloride reported by Tamele, Ott, Marple, and Hearne[8] indicate that the following series of compounds are easily derivable from the polychloride products of the chlorination of isobutane:



where X is a Cl or H atom and Y is H, Cl, OH, NR_2 (R is H or alkyl), OC_2H_{51} and probably also CN, SH, Br and I.

Further, on the basis of the work of Burgin, Hearne, and Rust[4] on the addition of hypochlorous acid to β-methyl allyl chloride and β, β-dimethyl vinyl chloride, it appears quite likely that similar reactions should occur for this series of compounds, that is,



where X and Y are same as above.

Such a series of compounds offers an indefinite number of synthesis possibilities. In addition, this series of compounds provides a source for testing points of theoretical interest, such as the effect of substituents upon the manner of addition to the double bond, and upon the direction of opening of the epoxide ring.

The derivatives obtained from the polychloride products of the chlorination of isobutane (those listed in Table I) were found to give no high polymers under conditions ordinarily employed for polymerization.

The authors want to express their appreciation to Dr. A. L. Henne for his helpful criticisms and suggestions, and to the Kansas Industrial Research Foundation under whose sponsorship a large part of this work was done.

A Discussion of the Mechanism for the Dehydrochlorination Reaction.

The kinetic data of Hughes and Ingold can be used to explain the products of each of the reactions given on page 1. The excellent

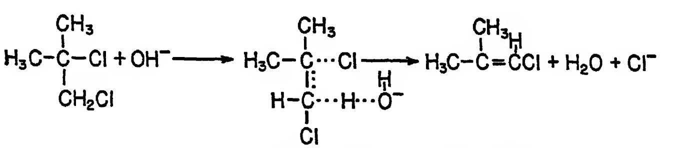
and highly informative kinetic studies of these investigators[9] show that in strongly alkaline solutions a hydroxide ion extracts a proton from an alkyl halide with simultaneous separation of the halide ion.[10] This reaction, called E2, is bimolecular and competes at all times with the bimolecular nucleophilic substitution (S_N2) in alkaline solution. The kinetic data of Hughes and Ingold[11] indicate that the rate of the S_N2 mechanism decreases very rapidly in the order primary alkyl halide $>>$ secondary alkyl halide $>$ tertiary alkyl halide while the E2 mechanism increases rapidly in the order primary alkyl halide $<$ secondary alkyl halide $<$ tertiary alkyl halide. Hughes[9] has pointed out that as a result of this relationship ethyl halides under the most favorable conditions for elimination give only 1% ethylene, while isopropyl halides give up to 80% propylene, and tertiary butyl halides yield 100% isobutylene. It is presumed by us that these same relative rates of the E2 and S_N2 mechanisms reported for the various monochlorides (primary, secondary, and tertiary) should be applicable to the polychloride derivatives of isobutane which contain a tertiary chlorine atom (In these cases, however, the absolute rates of these processes would be expected to be quite different).

[10]Further proof that this process is a synchronous mechanism has been found by Skell and Hauser (J. Am. Chem. Soc., 67, 1661 (1945).

To illustrate, let us consider each of the three dehydrochlorination reactions described on page 225, using 1,2-dichloro-2-methylpropane as an example of a typical polychloride derivative of isobutane (containing a tertiary chlorine).

(1) Dehydrochlorination in aqueous sodium hydroxide.

Since the E2 mechanism is bimolecular, that is, dependent upon the hydroxide ion concentration, the hydroxide ion attacks and extracts the most acidic hydrogen in the polychloride molecule (see page 227 for discussion of the most acid hydrogen atoms). This may be represented as follows:

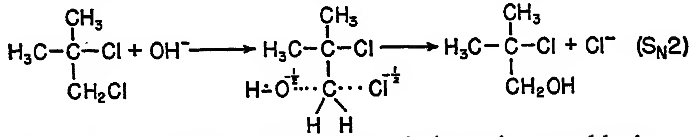


(E2)

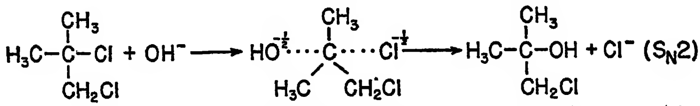
Transition State — *B,B*-dimethlvinyl chloride

The following reactions were not observed because of their relatively slow rates as compared with that given above.

(a) Nucleophilic substitution of the tertiary chlorine atom



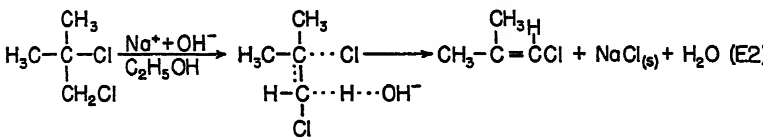
(b) Neucleophilic substitution of the primary chlorine atom



(c) An E2 type mechanism involving the primary chlorine atom cannot take place because there is no β-hydrogen atom that can be removed by the hydroxide ion.

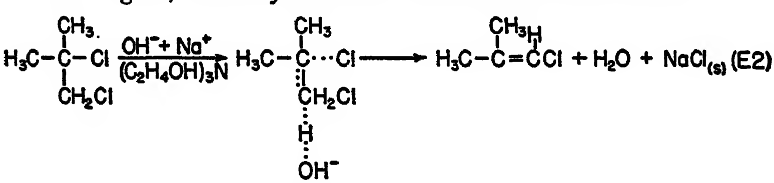
(2) Dehydrochlorination in alcoholic sodium hydroxide.

The mechanism is identical with that in (1), the only essential difference being that the reaction solvent is ethyl alcohol in this case.



(3) Dehydrochlorination in the triethanolamine-sodium hydroxide system.

Here again, the only essential difference is the solvent.



By treating any of the polychloride derivatives of isobutane investigated in this study in the manner described above for 1,2-dichloro-2-methyl propane, the products of each of the reactions reported on page 225 can be explained. In case the dehydrochlorination produces allyl chlorine atoms, secondary metathetical reactions give corresponding derivatives as discussed on page 227. Derivatives corresponding to the structure of the allylic olefins are obtained in each case since the reaction conditions are those requiring bimolecular metathesis, and as Hughes[12] points out it is only under conditions where the substitution reaction is monomolecular that mixtures of products result. (For example, in the reaction of γ-methyl allyl chloride with ethyl alcohol, the bimolecular reaction gives exclusively ethyl γ-methyl allyl ether, while the mononolecular

Structural Formula	Boiling Point	Density	Index of Refraction
$H\overset{Cl}{C}=\overset{CH_3}{C}-CH_3$ 1-chloro-2-methy-propene-1	b.p.$_{735}$=67.0-67.8°C	———	N_0^{25} =1.421
$Cl\overset{Cl}{C}=\overset{CH_3}{C}-CH_3$ 1,1 dichloro-2-methyl-propene-1	b.p.$_{735}$=107.5-108.5° C	———	N_0^{25} =1.454
$Cl\overset{H}{C}=\overset{CH_3}{C}-CH_2OH$ 3-chloro-2-methyl allyl alcohol	b.p.$_{735}$ =162-163° C b.p.$_{50}$ = 93° C	d_4^{25} =1.1232	N_0^{25} =1.4705
$Cl\overset{Cl}{C}=\overset{CH_3}{C}-CH_2OH$ 3,3 dichloro-2-methyl allyl alcohol	b.p.$_{735}$ =183.5-184.2°C b.p.$_{14}$ =81° C	d_4^{25} =1.3111	N_0^{25} =1.4974
$Cl\overset{H}{C}=\overset{CH_3}{C}-CH_2OC_2H_5$ 3-chloro-2-methyl allyl ethyl ether	b.p.$_{735}$ =138-139°C b.p.$_{12}$ =35-36° C	d_4^{25} =0.9862	N_0^{25} =1.4380
$Cl\overset{Cl}{C}=\overset{CH_3}{C}-CH_2OC_2H_5$ 3,3 dichloro-2-methyl allyl ethyl ether	b.p.$_{735}$ =166-167°C b.p.$_{12}$ =56.5-57.0°C	d_4^{25} =1.1231	N_0^{25} =1.4583
$H\overset{Cl}{C}=\overset{CH_2OC_2H_5}{C}-CH_2OC_2H_5$ 3-chloro-2-ethoxymethyl-allyl ethyl ether	b.p.$_{735}$ =171-172° (decomp) b.p.$_{12}$ =62-63° C	d_4^{25} =1.3991	N_0^{25} =1.5054

substitution reaction gives a mixture of ethyl α-methyl allyl ether and ethyl γ-methyl allyl ether.)

Experimental

I. Reactions of the Chlorides of Isobutane Obtained by Chlorination.

(1) Aqueous sodium hydroxide or aqueous silver oxide-sodium hydroxide reactions.

(a) 103 grams (0.640 moles) of 1,1,2-trichloro-2-methyl propane ($b.p._{49}$=66.7—67.1, uncorrected) were refluxed with constant stirring with 200 grams (4.00 moles) of sodium hydroxide in approximately 500 cc. of water at 100° for three days. Steam distillation gave 29 grams of crude product. Distillation of this material gave b.p. 50-98°, 0.5 grams; b.p. 105-115°, 2.0 grams; m.p. 115-260°, 0.5 grams; b.p. 264-270°, 22 grams; residue, 3 grams. Rectification of the fraction b.p. 264-270° at reduced pressure gave: $b.p._{49}$=150-170°, 3 grams; $b.p._{49}$=170-173°, 16 grams; residue, 2 grams.

The small amount of material b.p. 105-115° apparently is 1,1-dichloro-2-methylpropene-1, b.p. 107.5-108.5° (5). The main product of the reaction $b.p._{49}$=170-173° was not identified. Qualitative tests showed this material contained chlorine. It was insoluble in water, added bromine in carbon tetrachloride very readily, and was easily oxidized by dilute alkaline permanganate, but gave no further tests for functional groups. It is possible, as the tests indicate, that this material may be a dimer or trimer of 1,1-dichloro-2-methylpropene-1.

(b) The hydrolysis of 1,2,3-trichloro-2-methylpropane under alkaline conditions to give 3-chloro-2-methylallyl alcohol has been described by Rogers and Nelson.[6]

Our experimental procedure and results are nearly the same as these authors and will not be repeated here.

(c) 100 grams (0.510 moles) of 1,1,2,3-tetrachloro-2-methylpropane (bp_{49}=103.2-104.2, uncorrected) were refluxed with constant stirring with 280 grams (1.65 moles) of silver nitrate and 150 grams (3.7 moles) of sodium hydroxide in suspension (as silver oxide) in 750 cc. at 100° for three days. The reaction product was steam distilled from the resulting mixture, and dried over anhydrous sodium sulphate, giving 36 grams of crude product. Upon purification by fractionation this material had the following physical properties: $b.p._{735}$ = 183.5-184.2°; $b.p._{14}$ = 81°; $D_{25/4}$ = 1.3111; $n_{25/D}$=1.4974. It is a slightly yellow colored liquid which does not change upon long standing. The odor resembles the alcohol of (b).

Identification: Qualitative tests showed this substance to contain

inert chlorine, a double bond, (which was readily oxidized by permanganate, but which added bromine only with great difficulty, if at all), and a hydroxyl group, as shown by a positive ceric nitrate test and the formation of a derivative with phenyl isocyanate. A determination of the molecular weight by the freezing point depression of benzene gave 147. On the basis of these results, and the structure of the starting tetrachloride, the most likely structure for this substance 3,3-dichloro-2-methylallyl alcohol (molecular weight 141). The physical constants given by Kirmann and Jacob[7] for this substance, obtained by a different method, $b.p._{12}=78\text{-}79°$; $d^{20}=1.298$; $n_{20/D}=1.493$ are in close enough agreement to complete the identification.

The theoretical yield for this reaction is 72 grams. The percentage yield was 50%.

(2) Triethanolamine-Sodium Hydroxide Reactions.

The following series of reactions were run in 2 liter flasks with mercury seal stirrers. The reaction mixtures were refluxed at 70-110° from one to two hours with constant stirring, and then the volatile matter was distilled from the reaction vessel. The following data give the reactants and the reaction products, and their identifications. The yields, in those cases where a product is reported, probably can be improved by use of larger quantities of reactants.

(a) 100 grams (0.787 moles) of 1,2-dichloro-2-methylpropane ($b.p._{49}=33.4\text{-}33.6°$) were treated with 60 grams (1.50 moles) of c.p. sodium hydroxide pellets suspended in 800 grams of triethanolamine (Carbide and Carbon, 90%). A milky white distillate b.p. 55-70° was collected, and upon drying over calcium chloride gave 54 grams of crystal clear product. The material has a b.p.=107-108° upon distillation.

Identification: This product was shown by qualitative tests to contain a double bond (it added bromine slowly, but equivalent to double bond, and was readily oxidized by permanganate) and to contain inert chlorine (gave a precipitate with alcoholic silver nitrate upon fusion). A molecular weight determination by the Victor Meyer method gave 96.

On the basis of this evidence the product would more likely be 1-chloro-2-methylpropene-1 than 3-chloro-2-methylpropene-1 (molecular weights= 90.5). Beilstein[5] gives the $b.p._{775}$ the former as 68-69° and for latter, b.p.=71.5-72.5°. This identifies the product as 1-chloro-2-methylpropene-1.

The theoretical yield for this reaction is 72 grams. The percentage yield was 75%. This product, 1-chloro-2-methylpropene-1, has a high vapor pressure at room temperature and it was necessary to use a very efficient condensing system. The trial reported above was one of several similar ones made and is the one carried out under the most careful conditions. Adequate precaution must be taken at the start of the reaction for it is very exothermic and will start reacting suddenly if heated too fast, resulting in the eruption and loss of product and starting material.

(b) 76 grams (0.60 moles) of 1,3-dichloro-2-methylpropane ($b.p._{49}$=60.0-60.8°, uncorrected) were treated with 40 grams (1.00 mole) of sodium hydroxide pellets suspended in 725 grams of triethanolamine. The only distillate collected was a small amount of water soluble material (probably largely water), yet a reaction must have taken place as evidenced by the heat liberated, the appearance of a precipitate of sodium chloride in the triethanolamine, and the fact that none of the original dichloride could be distilled from the reaction mixture. However, no attempt was made to isolate the main reaction product, which probably was a chlorine containing tertiary amine.

(c) 87 grams (0.54 moles) of 1,1,2-trichloro-2-methylpropane were treated with 46 grams (1.2 moles) of sodium hydroxide pellets suspended in 735 grams of triethanolamine. The distillate amounted to 50 grams (after drying over calcium chloride) of 1,1-dichloro-2-methylpropene-1, b.p.=107-108°, identified on the basis of the structure of the original trichloride, and by comparison of the boiling point with that given in the literature[5] for 1,1-dichloro-2-methylpropene-1, b.p.=107.5-108.5°.

The theoretical yield for this reaction is 67 grams. The percentage yield was 75%. The same precautions noted in (a) apply to this reaction.

(d) 201 grams (1.24 moles) of 1,2,3-trichloro-2-methylpropane, ($b.p._{49}$=81.2-81.8°, uncorrected) were treated with 100 grams (2.50 moles) of sodium hydroxide pellets suspended in 800 grams of triethanolamine. A distillate consisting of water and a very small amount of unreacted trichloride was collected. Here again, as in (b), the same type of evidence indicated that a reaction did take place. Further evidence is as follows: The residue of the reaction was treated with a large quantity of water, and warmed, giving rise to the separation of heavy oil layer from the water layer.

This oil upon distillation at reduced pressure was found to be

a water-insoluble, chlorine-containing, amine, but was not further investigated.

(e) 150 grams (0.758 moles) of 1,1,2,3-tetrachloro-2-methylpropane (b.p.=103.9-104.9°, uncorrected) were treated with 60 grams (1.50 moles) of triethanolamine. Practically no distillate was obtained, and there was the same evidence of a reaction as in (b) and (d).

(3) Absolute Alcohol-Sodium Hydroxide Reactions.

The following series of reactions were run in 2 liter flasks with mercury seal stirrers. The reaction mixtures were refluxed at 80° for two hours with constant stirring. One to two liters of water was then added to the reaction mixture resulting in the separation of the crude product which was dried by passing over anhydrous sodium sulfate in each case. The following data give the reactants, the reaction products, and their identifications. In every case, there was immediate formation of a heavy sodium chloride precipitate.

(a) 100 grams (0.787 moles) of 1,2-dichloro-2-methylpropane ($b.p._{49}$=33.4-33.6°) were treated with 60 grams (1.50 moles) of c.p. sodium hydroxide pellets in 400 cc. of commercial absolute alcohol. 40 grams of crude 1-chloro-2-methylpropene-1, b.p.=66-70° was obtained.

The theoretical yield for this reaction is 72 grams. The percentage yield was 56%.

(b) 75 grams (0.60 moles) of 1,3-dichloro-2-methylpropane ($b.p._{49}$=60.0-60.8 C., uncorrected) were treated with 50 grams (1.25 moles) of sodium hydroxide pellets in 400 cc. of commercial absolute alcohol. A rough distillation of the resulting material gave: b.p.= 70-86°, 4 grams; b.p.=87-95°, 28 grams; residue, 11 grams (apparently formed by decomposition).

Identification: On the basis of the structure of the original dichloride, the products possible by this dehydrohalogenation and secondary reactions are: (x) 2-methylallyl chloride, (y) 2-methylallyl alcohol, or (z) 2-methylallyl ethyl ether. Porgorshelski[8] has reported in the literature the following constants of these compounds: (x) b.p.=70-73°; (y) b.p.=114°; (z) b.p.=87.5-88.5°. On this basis the fraction b.p.=87-95° is largely the above given ether (z). This is supported by the marked similarity in the fruit like odor of this product to the ether obtained in (3e).

The theoretical yield for this reaction is 60 grams. The percentage yield was 47% on the basis of the fraction b.p.=87-95°.

(c) 102 grams (0.630 moles) of 1,1,2-trichloro-2-methyl-

propane ($b.p._{49}$=66.7-67.1°, uncorrected) were treated with 50 grams (1.25 moles) of c.p. sodium hydroxide pellets in 400 cc. of commercial absolute alcohol. Distillation of the crude product gave 48 grams of 1,1-dichloro-2-methylpropene-1, b.p.=107.5-108.5°.

The theoretical yield is 73 grams for this reaction. The percentage yield was 62%.

(d) 100 grams (0.620 moles) of 1,2,3-trichloro-2-methylpropane, $b.p._{49}$=81.2-81.8° were treated with 40 grams (1.00 mole) of sodium hydroxide pellets in 400 cc. of absolute alcohol. 60 grams of a crude product were obtained. Distillation gave b.p.=100-137°, 5 grams; b.p.=138-143°, 45 grams; residue, 7 grams.

A sample of the fraction b.p.=138-143° purified by fractionation gave the following physical constants: $b.p._{12}$=35-36°, $b.p._{735}$ =138-139°, $d_{25/4}$=0.9862, $n_{25/D}$=1.4380. The substance on fractionation is a nearly clear liquid, with the same fruit-like odor of the ethers obtained in (b) and (e), but on standing becomes dark.

Identification: This product contains inert chlorine as qualitative tests showed. Only four chlorine containing compounds are possible by the dehydrohalogenation and the secondary reactions which may follow, namely: (α) 1,3-dichloro-2-methylpropene-1, (β) 3-chloro-2-chloromethyl propene-1, (γ) 3-chloro-2-methylallyl ethyl ether, and (δ) 2-chloromethylallyl ethyl ether. The boiling point of (α), b.p.=131.-132.5°, reported by Porgorshelaki[8] and Mooradian and Cloke[12], eliminate (α) as a possibility. The physical constants of the latter authors for (β), b.p. 138-138.3°, $d_{20/4}$= 1.1782, and $n_{20/D}$=1.4754, likewise eliminates (β). (δ) may be eliminated as a possibility since it possesses a reactive allyl chlorine atom, which the qualitative tests indicate not to be present, and which would not be expected to resist replacement by the ethoxy group under the experimental conditions. By a process of elimination, this establishes the structure of this substance to be that of (γ). This identification is in agreement with the nature of the physical properties of this substance and with the theoretical considerations discussed in the last section.

The theoretical yield for this reaction is 84 grams. The percentage yield based on the fraction b.p.=138-143° was 54%.

(e) 93 grams (0.47 moles) of 1,1,2,3-tetrachloro-2-methylpropane ($b.p._{49}$=103.9-104.9°, uncorrected) were treated with 40 grams (1.0 mole) of sodium hydroxide pellets in 400 cc. of commercial absolute alcohol. 67 grams of a crude product with a distinctive fruit-like odor were obtained. Distillation gave: b.p.=78-

161°, 6 grams; b.p.=162-167°, 50 grams; residue, 8 grams. Purification of fraction b.p.=160-165° by fractionation gave a substance with the following physical properties: $b.p._{785}$=166-167°; $b.p._{12}$=56.5-57.0°; $d_{25/4}$=1.1231; $n_{25/D}$=1.4583.

Identification: Kirrmann and Jacob[7] obtained 3,3-dichloro-2-methylallyl ethyl ether upon treating 1,1,3-trichloro-2-methylpropene-1 with sodium ethylate in the cold. They give the following physical properties for this ether: $b.p._{12}$=56°; $d_{20/4}$=1.1285; $n_{20/D}$= 1.4610. A comparison of the physical constants identifies the reaction product as 3,3-dichloro-2-methylallyl ethyl ether.

The theoretical yield for this reaction is 79 grams. The percentage yield was 63% based on the fraction b.p.=162-167°.

(f) 100 grams (0.510 moles) of 1,2,3-trichloro-2-chloromethylpropane ($b.p._{20}$=99.6-100.8°, uncorrected) were treated as above with 35 grams (0.88 moles) of sodium hydroxide in 400 cc. of commercial absolute alcohol. 80 grams of material resulted. Distillation gave: b.p.=78-167°, 6 grams; b.p.=168-182°, 61 grams; residue 9 grams. Fractionation under reduced pressure of the fraction b.p.= 168-182° gave the following results: $b.p._{12}$=58-62°, 7 grams; $b.p._{12}$=62-67°, 19 grams; $b.p._{12}$=67-80°, 30 grams; residue, 5 grams. The fraction $b.p._{12}$=67-80° boiled uniformly over the range of temperature and could not be separated further by fractionation. The fraction $b.p._{12}$=62-63° had the following physical properties: $b.p._{785}$=171-172° (decomposes); $d_{25/4}$=1.3991; $n_{25/D}$ =1.5054.

Identification: The substance of this fraction possesses the same type of distinctive odor possessed by the ethers formed in (b), (d), and (e). The following structures and corresponding molecular weights are those which it is possible to obtain by the dehydrochlorination (and followed by conceivable secondary reactions) of 1,2,3-trichloro-2-chloromethylpropane:

(1) $HC(Cl)=C(CH_2Cl)-CH_2Cl$, 160 (4) $HC(Cl)=C(CH_2OH)-CH_2OH$, 123

(2) $HC(Cl)=C(CH_2OC_2H_5)-CH_2Cl$, 169 (5) $HC(Cl)=C(CH_2OH)-CH_2OC_2H_5$, 151

(3) $HC(Cl)=C(CH_2OH)-CH_2Cl$, 141 (6) $HC(Cl)=C(CH_2OC_2H_5)-CH_2OC_2H_5$, 178.5

A determination of the molecular weight of the substance of fraction $b.p._{12}$=62-63° by the freezing point depression of benzene gave 175. These data eliminate (1), (3), (4), and (5) as a possible structures, and indicates that (3) is the most likely. This conclusion

is in agreement with the odor which showed none of the disagreeable characteristics of allyl chlorine compounds, and with the likelihood that an allyl chlorine atom could not exist unreacted in absolute alcohol at reflux temperature for two hours. It is felt that this is sufficient evidence for accepting structure (6), but it may be desirable to consider this structure as tentative, awaiting further experimental confirmation.

Bibliography

(1) Taft, R. W., Jr., and Stratton, G. W., Industrial and Engineering Chemistry, in press.
(2) Whaley, A. M., Private communication.
(3) Tamele, M., Ott, C. J., Marple, K. E., and Hearne, G., Ind. Eng. Chem., 33, 115 (1941).
(4) Burgin, J., Hearne, G., and Rust, F. F., Ind. Eng. Chem., 33, 385 (1941).
(5) Beilstein, Vol. I, p. 209.
(6) Rogers, A. D., and Nelson, R. E., J. Am. Chem. Soc., 36, 1028 (1936).
(7) Kirrmann, A., and Jacob, R., Bull. Soc. Chim., 7, 581-93 (1940); also C. A., 36, 3507 (1942).
(8) Porgorshelaki, Z., J. Russ. Phys. Chem. Soc., 36, 1129-1184 (1904); Chem. Zentra, 76, (1), 668 (1905).
(9) Hughes, E. D., J. Chem. Soc., 978-9 (1946).
(10) Hughes, E. D., Ingold, Masterman, and McNultz, J. Chem. Soc., 899 (1940).
(11) Hughes, E. D., J. Chem. Soc., 974 (1946).
(12) Mooradian, and Cloke, J. Am. Chem. Soc., 67, 942 (1945).

Report of the Kansas Academy Delegate to The Academy Conference at Boston

JOHN C. FRAZIER
Kansas State College, Manhattan

The conference was called to order at 4:00 p. m., Friday, December 27, 1946, at the Statler Hotel in Boston by the Chairman, Dr. E. F. Degering. There were 28 delegates representing 24 academies of science present as was Dr. E. R. Moulton, Permanent Secretary, and Dr. Otis W. Caldwell, General Secretary, of the A. A. A. S. A nominating committee composed of A. H. Bragg (of Oklahoma) as chairman and Dr. A. R. Middleton (of Kentucky) and Dr. G. W. Bladyes (of Ohio) was appointed. They nominated Dr. Howard H. Michaud (of Purdue University) as chairman of the conference for 1947, and Dr. Austin R. Middleton (of the University of Louisville) as secretary. Both were unanimously elected.

Dr. Caldwell presented the greetings of the A. A. A. S. and then spoke of the responsibilities of the affiliated academies for the improvement of relations to educational and industrial enterprises of the respective states, the preparation of scientific personnel, the sponsoring of science clubs, and the development of the Junior Academy as a valuable educational channel for directing interested and competent young people into the field of science. He also spoke briefly on federal research subsidies, stating that in certain instances this was interfering with the placing of A. A. A. S. research grants.

All this led to the consideration of the agenda prepared by Dr. Degering, which, as chairman, he presented in the form of four questions. 1, In what ways may a state academy improve its services and relations with its own state educational and industrial enterprises? 2, What can be done by the state academy toward developing additional scientific personnel? 3, How may the services of the Junior Academy be increased? 4, Should the state academies supplement their research funds? If so, how and for what specific purposes? The statement of these questions was followed by free commenting from practically all of the 28 delegates present. No definite conclusions could be drawn, but one had the feeling that the Kansas Academy was doing a very good job everything considered. We appear to have no problems that do not plague the other state academies.

Mr. Glenn O. Carter, representing the American Institute of the City of New York, presented a motion which, when amended by Dr. Ditmer of New Mexico, read: "We request the officers and directors of the A. A. A. S. to consider possible measures of working

through the academies of science for the encouragement of Junior Academies, or junior science activities, and prepare a report for publication on the present status of Junior Academies of Science in the United States, with recommendations." The motion was seconded and passed.

Dr. E. C. L. Miller of the Virginia Academy and the University of Virginia then presented a paper on "What Can and Should a State Academy of Science Do?" He developed this paper under five main points: 1, the Academy should continue to function as the common meeting ground for scientists of the state; 2, adhere steadfastly to the primary function, promotion of scientific research (especially in its sphere of influence but in the broad sense as well); 3, direct promising young people into the proper channels; 4, take an active part in the supervision of the administration of any government subsidy for scientific research; and 5, carry scientific information to non-scientific people, such as an open lecture at the annual meeting.

Minutes and Reports of the 79th Annual Meeting, Kansas Academy of Science, Lawrence, Kansas, April 2-3, 1947

The 79th annual meeting of the Kansas Academy of Science was held at the University of Kansas, Lawrence, Kansas, April 2-3, 1947. The Executive Council consisting of C. W. Hibbard (presiding), F. W. Albertson, P. S. Albright, D. J. Ameel, W. J. Baumgartner, J. W. Breukelman, S. V. Dalton, F. C. Gates, and J. C. Peterson met at 10 a. m., Wednesday, April 2nd, and transacted business. After much discussion concerning the financing of the *Transaction,* it was voted to cash and transfer to the General Fund the four U. S. Savings Bonds, which had matured in 1946, totaling $800. It was voted to set up a Research Endowment Fund, the interest from which shall be used in the furthering of research only, not transferable to the General Fund, and transfer to it the following:

4 Shares (620 to 623) Morris Plan, Wichita, 2%	$400.00
5 Shares (OS-1181) First Federal Savings and Loan of Kansas City at 2.5%	94.53
Certificates No. 1269, Western Shares	205.47
2 Shares (No. 0565 Full-paid) Green Co. B. & L. not over 4%	200.00
1 No. 46567H $500 U. S. Bond 1955-60 at 2⅞%	500.00
1 No. 11359K $100 U. S. Bond 1951-55 at 3%	100.00
1 No. 670L $50 U. S. Bond 1951-55 at 3%	50.00
1 No. 692B $500 U. S. Bond 1958-63 at 2¾%	500.00

It will also include the Reagan Bond (M1985650G, U. S. Savings Bond, 1955, at 2.5%.

It was voted to allow the two remaining U. S. Savings Bonds to mature and be handled as subsequent councils decide at such time.

It was voted to set up a Life Membership Fund to care for the obligations of the life member to the Academy and in payment for the *Transactions* during the life of such member. Any funds remaining upon his death shall be transferred to the Research Endowment Fund.

It was voted to transfer interest accumulated to March 31, 1947, other than that from the Reagan Fund, to the General Fund.

It was proposed that in Section 3, par. 2 of the constitution, $75 be substituted for $30.

It was agreed that the secretary should canvass life members, seeking contributions of at least $1 a year for the *Transactions* to equalize the financial obligations of the annual members or in case the life member has no need of the *Transactions* to authorize discontinuance.

It was voted to invite Dr. Burnett to become chairman in or-

ganizing an Industrial Research section at the Pittsburg meeting in 1948.

It was voted to invite a suitable person to be chairman in organizing a section in Agricultural Science at Manhattan in 1949.

At the general business meeting at 4:15 p. m., Wednesday April 2, the Academy transacted the following business.

The secretary's minutes, as printed on page 10 of the 1947 program were presented and accepted.

Upon Council recommendation (see Council minutes above) it was voted to set up a Research Endowment Fund and a Life Member Endowment Fund on the treasurer's books and to transfer certain bonds and certificates, outlined above, to the former.

It was voted, upon Council recommendation, to cash the U. S. Savings Bonds which matured in 1946 and the proceeds together with any accumulated interest from other sources, except that from the Reagan bond, to the General Fund.

It was proposed to amend the Constitution in section 3, paragraph 2, by substituting $75 for $30.

Reports of officers and committees were accepted as follows:

The report of the treasurer, S. V. Dalton, was presented and accepted.

The report of the auditing committee was presented by F. W. Albertson and accepted.

The report of the state aid committee was presented by W. J. Baumgartner, who called attention to increases in aid from the state and from the cooperating libraries in connection with the *Transactions*. The report was accepted.

The report of the committee on conservation and ecology called attention to cooperation with the Kansas Association of Garden Clubs; progress towards establishing Rock City as a State Park, the geographic center of U. S. as a National Monument; and study in areas to be flooded. The report was presented by W. H. Schoewe and accepted.

The report of the committee on natural history handbooks which indicated a possible second handbook on the ferns of Kansas, was presented by A. B. Leonard and accepted.

For the research awards committee, P. S. Albright reported none made in 1946. A month more time and power to award was granted this committee. Prof. Leonard reported the completion of the work of Dorothea Franzen, recipient of an earlier award, on

certain fossil and modern snails. The study will be published in a U. of K. Science Bulletin.

For the committee for the coordination of scientific groups and public relations, E. O. Deere reported progress.

The editor, Robert Taft, reported that volume 49 of the *Transactions,* with 462 pages has cost about $3.75 a page for 1700 copies, in contrast with 474 pages in volume 48 at $3.00 a page. He also called attention to the necessity of scientists taking the lead in keeping before the public that it is their work that furnishes the facts upon which various conservationists and long range planning boards operate.

The managing editor, W. J. Baumgartner, reported that the last part of volume 49 is almost ready for mailing.

The report of the committee on Finance, etc., was presented by F. W. Albertson.

Parts of a letter from Mrs. Reagan to Dr. Schoewe were read and the secretary was instructed to write a letter of appreciation of her desire to double the Reagan Fund.

At the general business meeting at 3:20 p. m., Thursday April 3, the Academy transacted the following business.

The secretary's minutes of the previous meeting were read and accepted, as minutes.

The report of the Academy delegate, John C. Frazier, to the Academy Conference of the A. A. A. S. was presented and accepted. A digest of this report appears in the *Transactions* (volume 50, p. 239).

The secretary was directed to inform Kansas senators and representatives that the Kansas Academy is enthusiastically in favor of an acceptable National Science Foundation, bills for which are before the present Congress and to inform Secretary Moulton.

The resolutions committee was presented by Dr. Mary T. Harman.

The report of the committee on change of title of publication was presented by R. Taft, who also expressed the dissenting views of the other members, Drs. Taylor and Smith. After considerable discussion a motion to refer the matter back to the same committee or to a new one was lost 36 to 9. The motion to amend the Constitution in Section 8, by substituting *Kansas Journal of Science* for *Transactions of the Kansas Academy of Science,* originally presented at Emporia in 1946, was further discussed but was lost in the vote: For, 13, against, 23.

The amendment to substitute $75 for $30 in Section 3, par. 2, necessitated by the great increase in cost of publication was well discussed and passed 40 to 6.

Chairman Breukelman of the nominating committee reported as follows:

President: J. C. Peterson, Kansas State.
President-elect: F. W. Albertson, Ft. Hays Kansas State.
Vice President: Paul G. Murphy, K.S.T.C., Pittsburg.
Secretary: Frank C. Gates, Kansas State.
Treasurer: S. V. Dalton, Ft. Hays Kansas State.
Additional members of the Executive Council:
  A. B. Leonard, University of Kansas.
  P. S. Albright, Wichita.
  A. C. Carpenter, Ottawa.
Editor of *Transactions*: Robert Taft, University of Kansas.
Associate editor (Geology): W. H. Schoewe, University of Kansas.
Associate editor (Botany): Frank C. Gates, Kansas State College.
Librarian: D. J. Ameel, Kansas State College.
Delegate to the A.A.A.S.: referred to the Council with power to select.

This report was adopted unanimously and the above officers declared elected.

Dr. Peterson took the chair, as the new president.

Upon motion by Taft, the secretary was directed to lay the financial situation regarding the *Transactions* before the life members and seek $1 a year each for the publication. Passed 27 to 8.

The applications of Hazel Molzen of St. John and Otis White of Wichita for life membership, voted upon favorably by the membership committee were brought up for action by the Academy. It was voted to accept them as life members, but for the *Transactions* they must pay $1 a year, as long as annual members have to pay $2. However the option of withdrawing from life membership and being refunded the difference between $30 and what they would have paid to date as annual members should be allowed each.

At the meeting of the new Council at 5 p. m., Thursday April 3, the following business was transacted:

Bills of the local committee were approved for payment.

It was voted to set aside up to $100 for the use of the Junior Academy committee and up to $50 for the use of the committee on educational trends in science teaching during the coming Academy year.

Adjourned.

FRANK C. GATES, *Secretary*

Transactions
Kansas Academy of Science

Volume 50, Nos. 3 and 4 | December, 1947

The Animal Industries of Kansas[1]

A. D. WEBER
Kansas Agricultural Experiment Station, Manhattan

Kansas has long been noted for its livestock production, an industry in which the state ranks nearly at the top of the list of states. In the article which follows, Dr. Weber, head of the department of animal husbandy, Kansas State College, has given his readers a general survey of this industry in the state, a survey which is another important contribution to those industries based on scientific endeavor which have been described in past issues of the Transactions. *Additional articles in this series will continue this plan begun some years ago and in the immediate future articles on the airplane industry and on the petroleum industry in the state will be published.*

For further information concerning the author of the present review, see page 266.—The Editor.

The green plant provides feed for livestock, and, directly or indirectly, every type of human food, as well as important raw materials for industrial use. The significance of these amazing accomplishments has been discussed in detail elsewhere,[2] and will not be elaborated upon here. Suffice it to say that livestock production is wholly dependent upon plant life, so whatever improves the quality or quantity of crop plants or native grasses grown in Kansas contributes significantly to the betterment of the animal industries.

On the other hand, livestock production, complemented as it is in Kansas by numerous processing and manufacturing enterprises, has a tremendous influence upon the commercial production of crop plants. Wheat excepted, the primary crops of Kansas are feed crops, which can best be utilized as livestock feed. Even wheat figures

Transactions Kansas Academy of Science, Vol. 50, Nos. 3 and 4, 1947.

[1]Contribution No. 153 from the Department of Animal Husbandry.

[2]L. E. CALL, *The Crop Industries of Kansas.* Trans. Kan. Acad. Sci., 47:1-6.

prominently in the over-all feed supply, approximately 30 per cent of the total production normally being fed in the form of milling by-products. Occasionally wheat is available at about the same price per pound as corn and other feed grains, and when this situation prevails considerable quantities of wheat are used for fattening hogs and beef cattle.

It is generally assumed that about 85 per cent of the total Kansas production of corn, sorghum grain, oats, and barley is utilized by livestock. From 95 to 100 per cent of the roughages including hay, silage, straw, sorghum stover, and cornstalks produced on Kan-

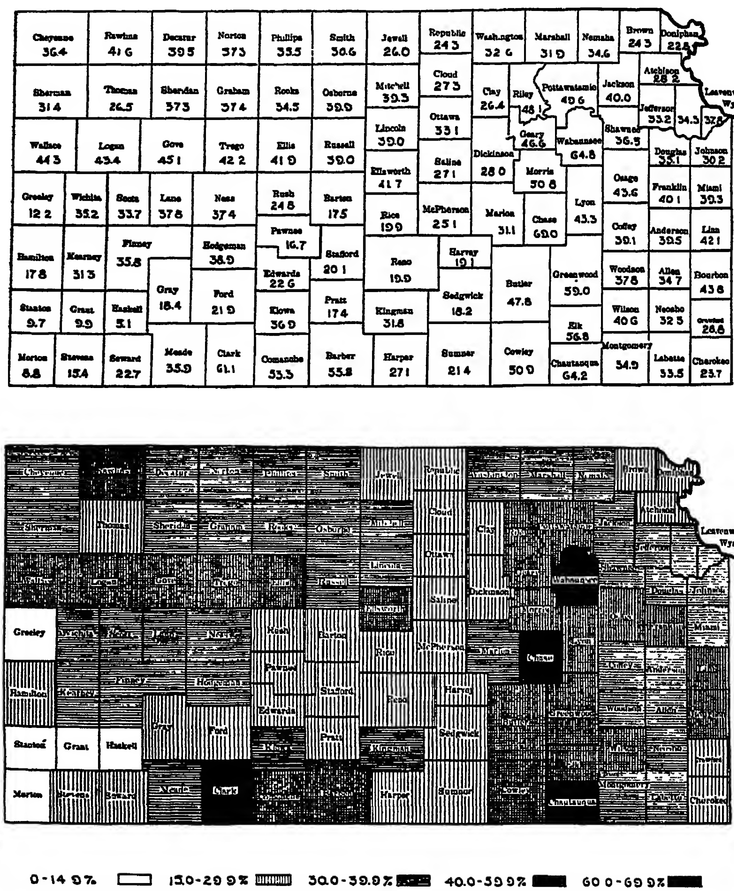


FIG. 1.—Per cent of total land area in pasture in Kansas in 1940.
Source: Adapted from data obtained from the 32nd Biennial Report of the Kansas State Board of Agriculture, 1939-1940. Actual percentage values for each county are given in the figure above the shaded one.

sas farms and ranches can be marketed only as feeds for livestock. Owing to their bulk, it is ordinarily not profitable to ship roughages any considerable distance and, as a consequence, they are usually fed to livestock in the localities where they are grown.

Thirty per cent or more of the farm land in Kansas is in pasture. Figure 1 shows the percentage of the land area of Kansas counties which is in pasture. Very little of this acreage is suited to cultivation.

While specific data are not available relative to the quantity of vegetation produced on Kansas native pastures, a conservative estimate would appear to be one ton of dry material per acre. Thus the total production is probably 15 to 20 million tons annually, all of which must be marketed through livestock if it is to yield a cash return.

The bluestem region is the most widely known pasture area in Kansas. In Figure 1, this region is represented by the heavily shaded area, beginning with Pottawatomie county at the northern end, and extending southward two to three counties in width into Oklahoma.

As many as 500,000 head of cattle have been brought into Kansas and grazed on the native grasses of the bluestem-pasture region in one season. While a somewhat smaller number of transient cattle have been brought to this region in recent years, the grass has been utilized efficiently by home-grown cattle plus the relatively large numbers shipped in from other states, particularly from Oklahoma and Texas.

Cattle move to the bluestem pastures during April and early May. Leases commonly terminate on October 15. Thin, aged steers from Texas formerly were grazed in large numbers in Kansas bluestem pastures. These steers often gained 250 to 300 pounds per head during the grazing season, and many of them were marketed as grass-fat cattle in July, August, or September. Under normal conditions, from 40 to 60 pounds of gain were made per acre of grass.

But economic conditions have changed, and fattening aged steers is no longer the most important grazing enterprise in Kansas. One reason for this change is the increasing demand for lighter carcasses which has developed in recent years. As a consequence, the supply of older steers has decreased materially, and new methods of utilizing bluestem grass with younger cattle have been developed. These new methods will be described in detail later in this article in connection with a discussion of the systems of beef production which are being used in different beef production areas of Kansas.

Because of their close relationship to the use of both crop and pasture lands, livestock contribute significantly to the conservation of agricultural resources. Grass and roughage are the principal products of soil conservation and diversified farming. As was pointed out previously, grass and roughage can be utilized best as livestock feed; in fact, unless they are disposed of in this manner sufficient monetary returns cannot be obtained to pay the cost of conservation practices. Feed grains also must find a satisfactory market through livestock if better farming practices are to be continued permanently.

Many thousands of acres of land under cultivation in Kansas should never be used for crop production because they are either too steep, too shallow, or too sandy for safe cultivation. It would be manifestly desirable to put these lands under permanent vegetative cover as soon as possible.

Pasture scene in the Flint Hills (the bluestem pastures).

Estimates of conservation authorities as to the increase in pasture acreage needed for a sound conservation program in Kansas average about 3½ million acres. If most economic returns accompany the attainment of this objective, more attention than ever will be given to livestock production.

That Kansas is primarily a livestock state is illustrated by the

source of the farm income over a period of years. For the years 1924 to 1944 inclusive, an average of 61 per cent of the gross Kansas farm income came from the sale of livestock and livestock products.[3]

In the five-year period from 1925 to 1929, income from the sale of farm products averaged $527,000,000 a year. The sale of crops accounted for a gross return of $201,205,000 and the sale of livestock and livestock products $283,411,000. Products worth $42,050,000 were consumed on farms.

During this five-year period the livestock income was distributed as follows: beef cattle, 33.9 per cent; hogs, 28.4 per cent; dairy products, 25.7 per cent; and sheep, 1.1 per cent.

Only in exceptional years of bumper wheat crops do the gross returns from the sale of crops exceed the gross returns from the sale of livestock and livestock products. Thus in 1945 the total value of all Kansas crops was $511,269,300. The total value of livestock production for that year was $382,487,000. Winter wheat production accounted for more than one-half of the total value of all crops produced.

Farm animals also make a notable contribution to the industrial wealth of the state. Kansas manufacturers depend largely upon various agricultural products for raw materials. Thus in a typical year (1937) before the war, various industries in Kansas manufactured products from 13 agricultural items whose value was 58 per cent of the value of all products manufactured that year. It is particularly significant that meat packing accounted for 31 per cent of the value of all manufactured products. Petroleum refining ranked second (19.3 per cent) while flour and other mill products were third (15.0 per cent).

The 1940 census of manufacturers revealed that there were 41 packing plants in Kansas in 1939. The numbers of animals slaughtered that year in these plants were as follows: cattle, 800,000; calves, 340,000; hogs, 2,380,000; sheep, 1,430,000. The total value of the packing house products from animals slaughtered was $144,000,000. Employment was furnished to 7,384 persons. This was more than twice as many people as were employed by any other industry.

Processes of the meat packing industry result in numerous by-products, some of which are used extensively as supplementary

[3]Data in this paper pertaining to livestock numbers and values were obtained from Biennial Reports of the Kansas State Board of Agriculture, Yearbooks of the United States Department of Agriculture, and U. S. Census Reports. In some instances computations were made from the original data.

feeds for livestock. Likewise, profits from dairying oftentimes are influenced significantly by the extent to which efficient use is made of the by-products of this industry in feeding livestock other than dairy cattle.

The movement toward the manufacture of these by-products for livestock feeding paralleled technical developments in applied nutrition and doubtless was hastened by rising costs of production and increased per capita consumption of all products. It has improved the competitive position of many industries by enabling them to enlarge operations and reduce distribution costs. Previously, many accessory products not only were unmarketable but their disposal as waste materials was a source of expense. Now, as manufactured by-products, they are an important source of revenue, and in some instances are said to be more profitable per pound than the main product.

Oilseed meals illustrate the economic significance of the utilization of by-products by livestock. In a personal communication to the writer, A. L. Ward, Director of the National Cottonseed Products Association, Inc., stated that if cottonseed cake and meal did not have an outlet as feed for livestock, cottonseed would give a 30 to 40 percent smaller return to the farmer than it does today.

Larger returns to producers of soybeans and flax also result because soybean and linseed meals, both of which are produced in considerable quantities in Kansas, find a ready outlet as feeds for livestock. But in countries such as Brazil where a dependable market has not been developed for oilseed cake as stock feed, this by-product is often used as fuel and hence does not have an appreciable effect on the returns obtained from the seed.

Prior to 1875, only those portions of meat animals which could be cured were considered worth saving by commercial slaughterers. Whole heads of hogs were buried in carload quantities, and the offal was dumped into rivers. Today, an imposing array of packing house by-products contributes to public health and wealth. Of these products, tankage, meat scraps, and bone meal are of particular importance as supplementary feeds for livestock. Packing house by-products and by-products from the processing of wheat and oil-bearing seeds are the most important by-product stock feeds produced in the United States and in Kansas.

The central livestock markets at Kansas City, Kansas, and Wichita also are important factors in the contribution of farm

animals to the industrial wealth of Kansas. Annual reports from these markets show livestock receipts as follows in 1941:

	Kansas City	Wichita
Cattle	1,387,000	289,081
Calves	325,000	73,876
Hogs	519,298	389,370
Sheep	2,225,645	228,518
Horses and mules	46,463	7,454

Approximately half of these animals were shipped by rail and the remainder by truck.

Community sales are becoming increasingly important in the disposition of Kansas livestock. Figures obtained from the office of the Livestock Sanitary Commissioner, Topeka, show that the number of community sales operating in Kansas has increased from 116 in 1941 to 147 in 1947. Data are not available on the number of animals sold at these sales.

It is not generally recognized that livestock are responsible for a sizable portion of the funds collected by taxation in Kansas. A recent study[4] revealed that cattle accounted for 20.87 per cent of the total tangible personal property valuation (exclusive of public service corporations) in Kansas in 1946. Oil and gas properties led the list with a valuation of 21.24 per cent of the total. Tractors, threshers, plows, etc., were third with 11.10 per cent, and motor cars were fourth with a valuation of 10.38 per cent.

Hogs, sheep, and goats, on the other hand, accounted for only 1.33 per cent of the valuation of personal property subject to taxation. It is evident, therefore, that insofar as livestock are concerned, cattle bear most of the tax burden.

This does not mean, however, that hogs and sheep are unimportant in Kansas agriculture. On January 1, 1946, Kansas ranked third among the states in number of sheep on feed, eleventh in hogs on farms, fourth in beef cattle, and sixth in number of all cattle. The low valuations placed on sheep and hogs for tax purposes are due, in large measure, to the early age at which lambs and pigs are marketed.

Most fall pigs are born either in late September or in October and are not subject to taxation because they are under six months old on March 1 when the tax statement is made, and only hogs six months old and over are required to be listed. Furthermore, spring pigs are marketed before March 1 of the following year, hence are not subject to taxation.

Since tax returns on sheep also are limited to those six months

---

[4] A. D. WEBER. *Assessment of Livestock.* Proc. Second Annual Conf. of Kan. Assessing Officers, Kan. State College, 1947, pp. 10-14.

old and over, the number taxed is not an indication of the importance of the sheep industry in Kansas. Spring lambs of the current year's crop either have not arrived by March 1 or are too young to be listed, while those produced the previous year have been sold long before the tax statement is made. Most western lambs brought into Kansas for pasturing on wheat or for dry-lot feeding are sold before March 1 and are not taxed.

Efficient utilization of grass, roughages, and feed grains is accomplished in Kansas by the use of systems of livestock production that are in accord with the productive capacities and conservation practices of individual farms and ranches. Differences in these capacities and practices reflect variations in rainfall, soils, adapted crops, size of farms, markets, and abilities of operators. Consequently, there is a wide range in types of farming.

Since beef production is not the only enterprise which must be

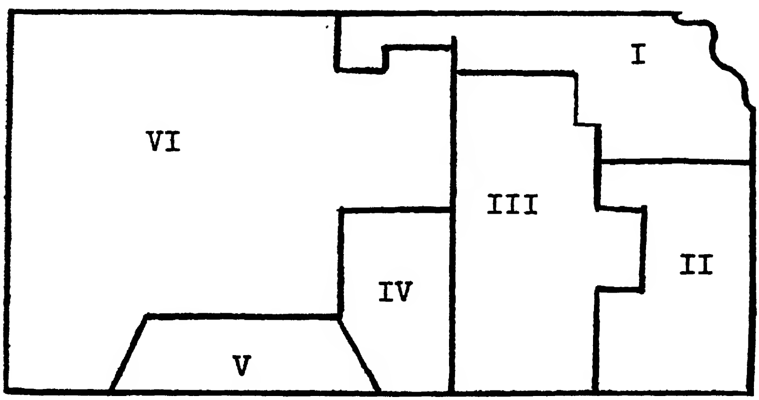


FIG. 2.—Beef Production Areas in Kansas.

considered in mapping types of farming in Kansas, type-of-farming areas do not coincide with the major beef production areas. Figure 2 is the result of an attempt to show the location of the beef production areas in Kansas. By comparing these areas with the principal pasture regions of the state (Figure 1), it will be seen that differences in areas are controlled, to a considerable degree, by the amount and kind of grass and its location in the state.

There is probably a greater diversity of production methods used in handling beef cattle than in handling any other class of livestock under Kansas conditions. Essential features of the important systems of beef production used in Kansas are given in the following outline.

1. *Production of feeder calves.* This system results in the production of calves averaging about 400 pounds at weaning time, when they are usually sold to go to other sections of Kansas or to other states where they are grown out and fattened. Herds of 100 or more cows have a distinct advantage over smaller herds from the standpoint of cost of production and of attracting the best buyers. Areas providing 12 months' grazing on native shortgrass pastures are best adapted to the production of feeder calves. Area V, commonly known as the Comanche Pool Area, and Area VI (Central and Western Kansas) are better adapted to the production of feeder calves than any of the other beef production areas of the state.

2. *Production of creep-fed calves.* This is an intensive system of beef production involving the maintenance of a cowherd and the feeding of grain to the calves in a creep enclosure where the cows cannot enter. This system is suited to small herds where the maintenance cost per cow usually is relatively high; hence it is particularly adapted to Areas I, II, III, and IV, where harvested feeds usually must be provided for wintering a cowherd. However, this system is being followed to a good advantage on some farms and ranches in Areas V and VI where grain is available for fattening the calves. The final product of this system is a slaughter calf weighing 700 pounds or more at 11 to 12 months of age.

3. *Deferred full feeding.* This system is especially popular in Areas II and III, but is also being used to a considerable extent in other areas on farms and ranches where summer grazing, good winter roughage, and some grain are available. The system involves three distinct phases which may be summarized as follows for good to choice range-bred steer calves purchased in the fall:

a. Wintered well on good quality roughage or green pasture plus enough grain to produce 200 to 250 pounds gain per steer in five to six months.

b. Grazed without grain for about 100 days beginning about May 1 for a gain of 100 pounds.

c. Full fed on grain for 100 days to produce a gain of approximately 250 pounds per steer.

The final product of this system is a well-finished, good to choice yearling steer averaging about 1,000 pounds and ready for market in the fall when relatively good prices usually are paid for this class and grade of cattle.

Several variations of the deferred full feeding system have been developed for heifer calves and yearling steers.

4. *Winter full feeding on grain.* The details of this system are varied depending upon the quality of cattle used. Good to choice cattle are fed to a relatively high degree of finish in Area I where an abundance of feed grain is produced and pasture is limited. Where there is a plentiful supply of silage, hay, and other good roughage, but only a limited supply of grain, the plainer grades of cattle are ordinarily used for winter full feeding since they respond well to this type of ration and are not fed to a high degree of finish. Winter full feeding on grain is practiced to a considerable extent in all beef production areas of the state except in Area V. Now that new combine-type grain sorghums have been developed which are equal to corn in nutritive value there is a good possibility that the winter fattening of beef cattle will increase in Area VI where these crops are well adapted.

5. *Wintering and summer grazing.* Good quality steer calves and yearling steers are used in this system in Areas III, V, and VI on many farms and ranches where feed grains are scarce but good roughages, winter pasture, and grass for summer grazing are available in abundance.

6. *Wintering.* Cattle handled in this system usually are wintered to produce somewhat more gain than where a full season's grazing is to follow the wintering period. The system is particularly adapted to farms in Areas IV, V, and VI having no native pasture for summer grazing. Beginning about 1930 increasing numbers of cattle have been grazed during the winter on wheat pasture and sold in the spring to be grazed or fed in dry lot elsewhere. The importance of wintering as a system of beef production in these areas is attested by the fact that the number of cattle grazed on wheat pasture is estimated to have exceeded 600,000 in some years and averaged around 350,000 since it has been followed commercially. The value of wheat pasture has reached enormous figures and has added much to the income of Kansas wheat growers.

7. *Summer grazing.* There are ranches in the bluestem-pasture region (Area III) that do not produce any roughages for winter feeding, or if roughages are produced the supply is not nearly sufficient to winter the number of cattle that can be pastured. On these ranches it is a common practice to lease the grass to an outsider. Sometimes arrangements are made to buy stockers in the fall, contract for their wintering, and then graze them a full season. An important limitation of summer grazing is that cattle must be purchased in the spring at the peak price and sold in the fall when prices

are normally lowest.

The system is not followed extensively in Kansas outside the bluestem-pasture region.

8. *Production of purebred beef cattle.* This is a highly specialized business and is carried on in all beef production areas of the state. Kansas ranks second to Texas in the production of purebred Herefords, and many good herds of Aberdeen-Angus and Shorthorns are found throughout the state.

In recent years the number of cattle other than milk cows on Kansas farms on January 1 has been approximately 3 million head, the highest on record since 1903. Kansas normally ranks third in cattle numbers, although occasionally Nebraska occupies that position.

Data are not available on the numbers of cattle handled under the different systems of beef production.

Horses and Mules

Owing to the mechanization of farm operations, numbers of horses and mules on Kansas farms have steadily declined since 1919. In that year the number of horses was estimated to be 1,153,000 and of mules 260,000. Numbers then declined steadily until in 1929 only 758,000 horses and 185,000 mules were reported to be on Kansas farms. Numbers have continued to decrease and indications are that the low point has not been reached, since there is little demand for draft horses and prices are established now on the basis of value per pound for slaughtering. On January 1, 1947 numbers of draft animals in Kansas were the lowest since 1878, official reports indicating that only 375,000 horses and 46,000 mules were left on Kansas farms and ranches.

The declining horse and mule population has made additional feed available for the production of meat animals and dairy products. Considerable interest in light horses has developed during the recent period of prosperity, but the numbers involved have been too small to influnce materially the downward trend in numbers of all horses. It appears likely, however, that present interest in stock horses will be maintenained even though prices may decline, since this type of horse has an important utility value on cattle ranches in Kansas.

Hogs

Hog production is centered largely in the eastern and northern counties of Kansas where corn is grown and legume pasture, partic-

ularly alfalfa, is a dependable crop. Production methods do not vary greatly in the areas of the state, owing to the fact that grain must figure prominently in hog rations irrespective of where the hogs are produced.

Since a dependable grain supply is so important for stable hog production, it is not surprising that hog numbers fluctuate greatly in Kansas. Numbers increase following good corn crops and tend to decrease sharply following a short crop or a failure. In recent years, the low point in hog numbers was reached in 1939 when 804,000 were estimated to be on farms on January 1. Numbers then steadily increased until 2,601,000 head were estimated to be on Kansas farms on January 1, 1944. Numbers have decreased slightly since then.

Swine production in Kansas has developed with the need for more intensive farm practices and greater diversification. It is probable that hogs will have an important place in the agriculture of western Kansas in the next decade or two, particularly if combine types of grain sorghums should be used extensively in cropping systems. Information already is available to indicate that these grains compare favorably with corn for fattening hogs and other farm animals. To date, however, farmers in western Kansas have shown little interest in hog production, and this lack of interest doubtless will continue so long as the present high price for wheat prevails.

Sheep

Sheep raising was associated with frontier conditions in Kansas. In the 1880's, the number of stock sheep on January 1 as reported by the Kansas State Board of Agriculture varied from about one-half million to one and one-fourth million head. In those years wool was the only product marketed from the range flocks in Kansas.

With the settlement of the country and the growth of diversified farming, the number of stock sheep on Kansas farms declined rather abruptly to about one-fourth million head, where it remained for almost 40 years. The collapse of the wool market at that time contributed significantly to the decline in sheep numbers. But even if wool prices had been favorable, new agricultural developments doubtless would have crowded sheep out to make room for new farming enterprises.

Increased use of wheat pasture for grazing western lambs when conditions have been favorable in recent years has boosted the number of sheep on farms on January 1 to the number equaling that of pioneer days. From a very small beginning in the 1930's, the

business has grown until the number of lambs grazed on wheat has advanced above one and one-third millions. The scale and extent of winter wheat pasture fattening of lambs in Kansas will always be subject to violent fluctuations from year to year, due to wide variations in soil moisture and winter growing conditions for wheat. There have been years since the development of wheat pasture feeding when there were practically no lambs pastured. Over a period of years during which this industry has been followed commercially the number of lambs pastured is believed to have averaged around 750,000.

Fattening of range lambs on threshed grains and ground sorghum roughages or legume hay has been carried on in all sections of

Lambs pasturing on Western Kansas winter wheat.

Kansas for some years. Increasing numbers of lambs also are being fattened at railroad feeding plants and at other large commercial feeding establishments in Kansas located within easy reach of the markets.

The sheep industry in Kansas is characterized by a marked degree of specialization. The most important phases of sheep production in Kansas include (a) Production of spring lambs from farm flocks; (b) Fattening range lambs on wheat pasture; (c) Fattening range lambs in dry-lot; and (d) Production of purebred sheep.

Dairying

Detailed information on the Kansas dairy industry was made available recently in a report by H. E. Dodge, State Dairy Commissioner.[5] Pertinent facts relative to the size of the industry and to the location of major producing areas in the state are summarized as follows in this report:

"During the ten-year period ending in 1945 Kansas cows produced an average of 3,113,000,000 pounds of milk annually. This milk had an aggregate value of more than a half million dollars, or an average value of $53,287,100 per year. In the same years the annual average value of the 775,300 milk cows of the state was only $43,045,800, or $10,241,300 less than the annual product of these

A dairy herd, Riley County, Kansas.

animals. The value of manufactured dairy products in Kansas annually exceeds 40 million dollars.

"In recent years the production of Kansas milk cows has brought in more income than was received from the harvested bounty of nearly eight million acres devoted to all crops except corn and wheat. Receipts from milk topped all Kansas livestock enterprises except beef cattle, and in a few years, hogs and poultry.

[5]H. E. Dodge, *The Kansas Dairy Industry*. Rpt. of Kan. St. Bd. of Agr., Vol. 55, No. 275:1-64.

"In 1945 the average Kansas dairy cow gave 4,120 pounds of milk which tested four percent butterfat. She produced 165 pounds of butterfat and was valued at $102.

"Kansas milk production is concentrated in thirty-one counties comprising four areas which together accounted for 48 per cent of the milk output during the ten years ending in 1945. Each of these counties has an average annual production of more than 40 million pounds. Ninety counties in the state averaged more than 10 million pounds annually, and 72 averaged over 20 million.

"Largest of the production areas is the group of eleven south central counties centering on the metropolitan markets of Wichita and Hutchinson. Reno, Sedgwick, and Sumner counties, the state's leaders, have annual records of more than 60 million pounds each, and McPherson, Marion, and Cowley counties each produce 50 to 60 million. Other counties in this district are Butler, Dickinson, Harper, Kingman, and Harvey.

"Eight counties immediately west and southwest of Kansas City supply the markets of Kansas City and Topeka; each produces 40 to 50 million pounds per year. These counties are Johnson, Franklin, Leavenworth, Jefferson, Lyon, Douglas, Osage, and Shawnee.

"Extreme southeast Kansas supports an important dairy industry in seven leading counties. Fifty to 60 million pounds come from Labette and Bourbon counties each year, and 40 to 50 million pounds from Montgomery, Neosho, Cherokee, Allen, and Crawford. This fine dairy region extends into southwestern Missouri.

"Fourth of the major milk areas of Kansas is a group of five northeastern counties along the Nebraska border. Fifty to 60 million pounds annually come from Marshall, Washington, Nemaha and Brown counties. Jewell county averages more than 40 million."

Poultry

Poultry production is primarily a family business in Kansas, and is engaged in more widely than any other one crop or livestock enterprise. In 1945, chickens, eggs and turkeys produced in Kansas had a market value of $86,605,000.

Selected References

ANDERSON, KLING
1942. *The Grasslands of Kansas.* Thirty-third Biennial Rpt. Kan. St. Bd. of Agr., pp. 144-160.
1946. *Range and Pasture.* Rpt. of Kan. St. Bd. of Agr., Vol. 55, No. 271:92-116.

AUBEL, C. E.
1943. *Swine Production in Kansas.* Kan. Agr. Expt. Sta. Bul. 314:1-76.

Call, L. E.
1944. *The Crop Industries of Kansas.* Trans. Kan. Acad. Sci., 47:1-6.
Corn Belt Livestock Marketing Research Committee.
1942. *Marketing Livestock in the Corn Belt Region.* So. Dak. Agr. Expt. Sta. Bul. 365:1-198.
Cox, Rufus F.
1939. *Feeding Range Lambs in Kansas.* Kan. Agr. Expt. Sta. Bul. 287:1-80.
Cox, Rufus F. and Weber, A. D.
1947. *Pasturing Cattle and Sheep on Winter Wheat in Kansas.* Contribution No. 152, An. Husb. Dept., Kan. Agr. Expt. Sta. (To be published in 35th Biennial Report of Kan. St. Bd. of Agr.)
Dodge, H. E.
1946. *The Kansas Dairy Industry.* Rpt. of Kan. St. Bd. of Agr., Vol. 55, No. 275:1-64.
Haag, Herman M., Parsons, Franklin L., Wilson, C. P., and McCoy, John H.
1945. *Transportation of Livestock by Motor Truck to the Kansas City Market.* Kan. Agr. Expt. Sta. Bul. 324:1-59.
Hodges, J. A., Elliott, F. F., and Grimes, W. E.
1930. *Types of Farming in Kansas.* Kan. Agr. Expt. Sta. Bul. 251:1-112.
Kansas State Planning Board.
1937. *Agricultural Resuorces of Kansas.* Kan. St. Col. Bul., Vol. 221, No. 10:1-227.
Malin, James C.
1942. *An Introduction to the History of the Bluestem-Pasture Region of Kansas.* Kan. Hist. Quart. 11:3-38.
Malott, Deane W. and Martin, Boyce F.
1939. *The Livestock and Meat-Packing Industry.* 64 pp. A reprint by Swift & Co., Chicago of Chapter III of the Agricultural Industries. McGraw Hill Book Co., Inc.
Mohler, J. C.
1926. *Poultry in Kansas.* Rpt. Kan. St. Bd. of Agr., Vol. 50, No. 179: 1-458.
1934. *Beef Cattle in Kansas.* Rpt. Kan. St. Bd. of Agr., Vol. 52, No. 211B:1-289.
Payne, Loyal F.
1936. *Poultry Management.* Kan. Agr. Expt. Sta. Circ. 178:1-77.
Reed. H. E.
1937. *Sheep Production in Kansas.* Kan. Agr. Expt. Sta. Bul, 275:1-72.
Sheets, E. W., *et. al.*
1921. *Our Beef Supply.* U.S.D.A. Yearbook. pp. 227-322.
Throckmorton, R. I.
1946. *Soil Conservation in Kansas.* Rpt. of Kan. St. Bd. of Agr., Vol. 55, No. 271:7-20.
Weber, A. D.
1944. *Balancing the Feed Supply with Livestock.* 34th Biennial Rpt. Kan. St. Bd. of Agr., pp. 83-99.
1945. *The Utilization of Industrial By-Products by Livestock.* Proc. Ind. and Agr. Conf., Kan. Agr. Expt. Sta. Rpt. No. 3:52-54.
1947. *Assessment of Livestock.* Rpt. of Proc. of Second Annual Conf. of Kan. Assessing Officers, Kan. St. Col. pp. 10-14.

"The Machine Age Will Be As We Make It"

What we have done to adapt the machines of war to the needs of those who fought in our defense can be done for the machines of peace. We are probably at the beginning of an ero of great scientific and industrial development. It will be a human tragedy if physicians and biologists do not sit in the councils of those who shape the instruments and the environments of man. All about us we can see the unhappy consequences of a great industrial civilization, created without adequate regard for the biological requirements of physical and mental health. Millions who come together in cities to use the machines of industry live under the pall of an unnatural atmosphere polluted by the products of the machine. Death stalks the highways at night in high-powered vehicles illuminated with disregard of the facts of vision. Machine-made noise is the constant lot of those who cannot escape to a more natural environment. But these are not necessary faults of the machines—for machines are as we make them. We can build them for our use or for our harm.

* * *

Science frees men from the hazards of ignorance and the uncontrolled domination of natural forces, but science and technology also create a complex civilization that severely taxes the biological capacities of the individual citizen. Each new scientific discovery that provides men with new powers creates new human problems and new dangers. We cannot, and we would not, retreat out of the scientific civilization we have created, and we cannot stand still. Either we will increase our understanding of the forces which shape our lives, and use them to our advantage or we shall fall victims to uncontrolled powers.

Scientific discovery is the exploration of the unknown, and I, for one, do not see how it is possible to direct an explorer through unknown territory. Because of this no man can plan or predict the future of civilization. But it is possible to modify its course and shape new developments to the benefit of men. The internal combustion engine that carries bombers on their missions of destruction is the same engine that cultivates the fields for starving millions. The slums of modern cities blight the lives and dwarf the spirits of men. But the same machines that build the slums can recreate the cities for human welfare. The aerial transportation that makes more difficult the control of epidemic diseases is also available for the swift transportation of sick and wounded.

The machine age will be as we make it. Science gives us the building stones of a better world. If our primary concern is for the machine and the power of machines, it will be a world in which flesh and blood are less real than paper and ink and celluloid and steel.

The blast of the atomic bomb awakened men to an awareness of the human implications of the forces controlled through science. The time is ripe to supplement the generous instinct for human welfare with aggressive action by those who are familiar with the biological needs of men. Only thus will it be possible to give men a life of usefulness and purpose—with machines as their tools for biologically and spiritually significant accomplishments.—Detlov W. Bronk, from "Physicians of the Machine Age," *Annals of Internal Medicine,* April, 1947.

The Editor's Page

Transactions
of the
Kansas Academy of Science
Published Quarterly
by the
KANSAS ACADEMY OF SCIENCE
(Founded 1868)
OFFICERS
John C. Peterson, Manhattan, President.
F. C. Gates, Manhattan, Secretary.
S. V. Dalton, Hays, Treasurer.

Vol. 50, Nos. 3 and 4 Dec., 1947

ROBERT TAFT, *Editor*

Large college enrollments in the post-war years are now taken for granted but even then it is surprising to find that there are over 37,000 students in attendance in the colleges of Kansas. That this is a large figure becomes evident when one realizes that approximately one out of every fifty Kansas inhabitants is a collegian enrolled in a Kansas college. This proportion is unusually high, for the national average is about one college student for every sixty-five inhabitants the country over. The present enrollment in Kansas colleges becomes even more astonishing when comparison is made with enrollments of 1900. At that time only one out of 400 inhabitants of the state was enrolled in a Kansas college.

Detailed enrollment figures of individual Kansas colleges for the fall of 1947 are given in the table on the opposite page. The data there assembled have been secured by the cooperation of the several college registrars involved, to each of whom the *Transactions* hereby expresses its thanks. Incidentally, it might be remarked in passing, the editor has seen no other list of Kansas colleges that approaches this list in completeness. The usual educational directories are incomplete and the editor, in a number of instances, has had to fall back on his personal knowledge in preparing the list. If any omissions have been made, the *Transactions* would be glad to have the added information. The recent attention given Utopia College at Eureka may suggest that this school has been forgotten. This school, however, has now 19 enrollees but, as planned at present, Utopia is not giving conventional college training. Short courses are given for adult students in economics and business; Utopia does not contemplate, according to their registrar, the offering of any courses in the natural or physical sciences.

Forty-two colleges and 37,000 college students in a state having a population of less than two million! Such records are a measure of the state's cultural aspirations — a high barometric reading, as it were, of the state's social atmosphere. We all can rejoice that these large figures undoubtedly reflect a desire for advanced training and sound knowledge, a desire that is wholly commendable.

ENROLLMENTS IN KANSAS SENIOR COLLEGES, FALL, 1947

1.	Baker University, Baldwin	640
2.	Bethany College, Lindsborg	420
3.	Bethel College, North Newton	439
4.	College of Emporia, Emporia	312
5.	Fort Hays Kansas State College, Hays	981
6.	Friends University, Wichita	576
7.	Kansas State College, Manhattan	7,158
8.	Kansas State Teachers College, Emporia	1,362
9.	Kansas State Teachers College, Pittsburg	1,899
10.	Kansas Wesleyan University, Salina	515
11.	McPherson College, McPherson	459
12.	Marymount College, Salina	266
13.	Mt. St. Scholastica, Atchison	401
14.	Ottawa University, Ottawa	580
15.	St. Benedict's College, Atchison	486
16.	St. Mary College, Xavier	375
17.	Southwestern University, Winfield	701
18.	Sterling College, Sterling	321
19.	Tabor College, Hillsboro	352
20.	Washburn Municipal University, Topeka	1,919
21.	Wichita Municipal University, Wichita	3,032
22.	University of Kansas, Lawrence and Kansas City	9,486
	Total	32,680

ENROLLMENTS IN KANSAS JUNIOR COLLEGES, FALL, 1947

1.	Arkansas City	236
2.	Central College, McPherson	105
3.	Chanute	242
4.	Coffeyville	482
5.	Dodge City	219
6.	El Dorado	281
7.	Fort Scott	267
8.	Garden City	129
9.	Hesston	187
10.	Highland	96
11.	Hutchinson	476
12.	Independence	300
13.	Iola	92
14.	Kansas City	684
15.	Paola (College of Paola)	104
16.	Parsons	266
17.	Pratt	125
18.	Sacred Heart, Wichita	81
19.	St. John's Lutheran College, Winfield	257
20.	St. Joseph's, Hays	21
	Total Junior College Enrollments	4,650
	Total Senior College Enrollments	32,680
	Grand Total, College Students in Kansas Colleges	37,330

These figures, however, could be used as a starting point for many serious studies—and studies which deserve attention. There are two of the many problems which arise from the huge influx of students to Kansas colleges which are of immediate concern to the scientific profession.

The first of these problems is the cost of scientific training. Are the people of Kansas willing to pay the cost of high-grade instruction in science? Few, if any, laboratories, class rooms and offices were built during the war and but little additional equipment was added to laboratory stocks. Since the end of the war a number of temporary and emergency measures have been taken to relieve such shortages but the fact remains that enrollments are now roughly twice the pre-war level and, to aggravate the situation further, costs of scientific equipment and supplies have also doubled. There has thus been a four-fold increase since 1941 in the cost of scientific equipment.*

*That this factor of four in the increased cost of laboratory supplies and equipment is not far off can be seen by the experience of a single department in one Kansas school. For the school year 1941-42, the department of chemistry of the University of Kansas spent some $15,000 for supplies and equipment. For the school year 1946-47, the estimated expenditure of the department, provided in part by the state and in part by private and governmental organizations, will be approximately $50,000 and this sum does not adequately provide for all necessary items, especially the very much more expensive ones of graduate instruction and research. The size of this last sum is some indication of the problem involved. Again, to emphasize the above point, one university estimated shortly before the war that its total cost for the four years' training of a graduate in chemistry was $1600.00; if this figure was general before the war, it would now take over $3000.00 to train graduates in chemistry, only a small share of which is borne by the student.

Even for elementary instruction, the current value of laboratory equipment and supplies may rise as high as fifty dollars or more for each student and thousands of students must be equipped. It is true that a considerable share of such equipment belongs to the permanent stock of a laboratory and is used over and over again. But with the great influx of students, more and more of this equipment must be purchased. Whether the present large enrollments will continue is, of course, problematical. *Manpower for Research*,† however, predicts for the next ten year gradually increasing enrollments in *science courses* beyond the present high levels, save for a small dip in the early 1950's.

As science instruction passes from elementary to advanced courses, the cost of individual equipment rises sharply and when graduate instruction in the sciences is provided, the cost staggers one not familiar with the situation. Measuring temperature with the precision attainable in modern research, for example, requires apparatus that costs at present $1,850.00; a one-dollar mercury thermometer, although useful for its purpose, is not adequate for many types of investigations. For the measurement of small electrical potentials, the cost of equipment may exceed $2,500.00 and if an electron microscope is required for a particular study, an expenditure in excess of $10,000 is necessary. Again, a single graduate student may need a spectrograph for the measurement of the character and intensity of light that well may cost as much as $15,000. These figures serve to illustrate that training in modern science and investigation is extremely costly.

Furthermore, the considerations made above take no account of the cost of actual instruction. Salaries of science instructors have been raised and must be raised further. Two-thirds of all science instructors in American institutions of higher education, according to the recent Federal survey *Manpower for Research* (p. 17), received annual salaries less than $4,000 in 1946 and probably the Kansas average was considerably less than this figure. Yet young men who have just completed their doctorate can command a higher wage than this in industry or government. Not only must Kansas institutions raise salaries to meet such competition but more competent instructors must be added. Well-trained and competent instructors, however, are scarce. Indeed because of this scarcity and the over-load imposed on older teachers and the lack of laboratory space and equipment, *Manpower for Research* (p. 23) makes the dismaying statement "All indications are that the quality of college and university science teaching in 1947 is markedly lower than before the war." And this in an age when scientific knowledge and research are not only essential to national welfare but may be necessary for the national existence.

---

†*Manpower for Research*, John R. Steelman, Washington, Oct. 11, 1947.

The financial problems thus raised are those that must be faced by every group sponsoring an institution of higher learning in Kansas, but of course the problem goes back eventually to each individual Kansan. In the so-called atomic age do Kansans wish to insure adequate training in the essential sciences for her students? If so, funds *must* be found. In this connection the editor again wishes to call attention to the suggestions made by the proponents of the National Science Foundation for financing science education.*

Still another serious problem is posed by comparing the statistics given in our table with the enrollments of 1941 in the teachers colleges of the state. In 1941, students enrolled in the three teachers colleges of the state (Hays, Emporia and Pittsburg) numbered 3347; in 1947, the total enrollment was 4242. That is, while most colleges have doubled their pre-war enrollment — a 100% increase — the teachers college enrollments have increased by only about 25% and the gain has occurred principally in one school. Although this fact is open to several interpretations, a quite obvious one is that other professions are, at present, more attractive than public school teaching. The number and quality of public school teachers, however, need to be increased as badly as do those in institutions of higher learning. Collegiate science training, to mention but one aspect of the problem, is vitally dependent upon the number and quality of public school teachers. For example, one well-known teacher of thirty years' experience in directing freshman chemistry in one of the largest universities of the country states "The main difficulties of students (in chemistry) have their roots less in chemistry than in English and arithmetic."† The need for better instruction, that is, for more and better qualified teachers, is especially striking in elementary mathematics. It is a constant cry of university teachers in freshman science courses that students are unable to solve the simplest problems in proportion and percentage.‡ Furthermore, this problem is also a regional one. Admiral Chester N. Nimitz has called attention to this strange phenomenon in his celebrated comments on the lack of elementary mathematical training in enlistees for the navy and in applicants for commissions. Based on tests given at naval recruiting stations, Nimitz remarked "It is to be noted that proficiency in arithmetic in the eastern part of the country was strikingly greater than that of the middle west and west. The lowest average mark east of the Mississippi was equal to the highest average mark west of the Mississippi."* Professor H. B. Reed, in the pages of these *Transactions* (September, 1944), has also called attention to a somewhat similar set of facts.

*These *Transactions*, September, 1947, p. 120; *Science and Public Policy*, John R. Steelman, Washington, August 27, 1947.

†Joel H. Hildebrand "War and the Decimal Point" *School and Society*, May 16, 1942, p. 544.

‡Hildebrand, cited before, states that in a simple test given to beginning chemistry students at the University of California, 60% of the graduates of one high school were unable to answer the problem "What per cent of eight is five?"

**North Central Association Quarterly*, January, 1942, p. 222.

Tests given to Kansas college seniors in one school showed that Kansas students ranked very appreciably below those of eastern schools in mathematics and in the physical sciences. Many factors must contribute to these results but lower standards and poorer teaching are undoubtedly among the most significant, for it is difficult to believe that a difference in native intelligence exists between inhabitants of East and West.

Kansas, in past years, has produced many of the national leaders in various scientific fields. If this reputation is to be maintained and—what is more important—if Kansas students are to be adequately trained, better teachers, more teachers, better equipment and more equipment are absolute necessities. Is Kansas willing to pay the price? The answer rests not only upon teachers themselves, upon the administrators and governing bodies of our educational institutions, but upon every thinking citizen of the state from the governor down to its humblest citizen.

* * *

The two problems described above and now confronting the scientific profession of Kansas are so pressing in the editor's opinion that they should have the immediate attention of all concerned. Further it is the task of the profession to call attention to these problems. In order that we may share in this task, a number of reprints of the above discussion have been printed and are available on request. It is urged that copies be distributed to all who will read and consider the problems before us for they are not only problems confronting the profession but—in the long run—every citizen as well.

* * *

Arthur D. Weber, the author of the feature article in this issue of the *Transactions,* is a native Kansan for he was born in Muscotah, Kansas, some forty-nine years ago. After graduation from Kansas State College

DR. A. D. WEBER

in 1922 he served for two years as farm manager and then turned to teaching and research, a profession which he has followed to this day. Graduate training at Kansas State College and Purdue University and teaching experience at the University of Nebraska and his alma mater have completed his professional career up to the present. He joined the faculty of

Kansas State College in 1931 and since 1944 has been head of the department of animal husbandry. Dr. Weber's special field of research is in the field of animal nutrition, especially of beef cattle but he is also an expert on the appearance of cattle for he has served frequently as judge at national shows and expositions. Without doubt he could also qualify as an expert on cattle from the standpoint of the consumer in which pleasant avocation he would doubtless have competition from many of his readers.

In addition to his numerous professional duties, Dr. Weber has found time to serve as president of a number of national organizations included among which are the American Society of Animal Production, the Farm House Fraternity and the Block and Bridle Club. A frequent contributor to technical and agricultural professional publications, Dr. Weber is also a well-known contributor to the more general agricultural press.

As the editor has remarked before in the pages of these *Transactions,* active workers in the scientific profession of the state are among the state's leading citizens and many times contribute more to the life and the well-being of the state than do those individuals whose names appear more or less daily on the front pages of the newspapers. The *Transactions,* however, is happy to award its order of merit to Dr. Weber, one of our state's leading citizens.

Scientific News and Notes of Academy Interest

Items for this column are solicited from all Academy members. For inclusion in any given issue they should be in the editor's hands at least three weeks before our publication dates, namely, the fifteenth of March, June, September and December.

If the reader has been observant, he will have noted that this issue of the *Transactions* is "Volume 50, Nos. 3 and 4." The purpose of making this issue both numbers 3 and 4 is to make our publication year coincident with the calendar year. Our next issue will be "Volume 51, No. 1, March, 1948." By making this change, the four issues of 1948 (March, June, September and December) will constitute volume 51. Previously our publication year extended into parts of two years.

The 80th annual meeting of the Academy will be held in Pittsburg, Kansas, this coming spring. The dates of the meeting have been definitely fixed as April 29 and 30 and May 1, and plans are actively under way that will provide a most excellent program. Dr. O. W. Chapman, professor of chemistry at Kansas State Teachers College, Pittsburg, has been appointed chairman of the committee on general arrangements. Be sure to reserve the dates above on your calendar for the meetings of the Academy.

What Have I Caught? a 24 page booklet by Dr. John Breukelman, professor of biology at Kansas State Teachers College, Emporia, has just been published by the state forestry, fish and game commission. The booklet describes in non-technical language the game and rough fishes of Kansas, together with a few minnows commonly used for bait, in an effort to help the fishermen of the state identify each day's catch. Over seventy line drawings by Ralph W. Haskell add greatly to the value of the booklet. Every Kansas fisherman with any curiosity at all will profit from a reading of this interesting little work. Copies may be secured by addressing the Director, State Fish and Game Commission, Pratt, Kansas.

Dr. E. Lee Treece and Mr. Mitchell Korzenovsky of the department of bacteriology, University of Kansas, have been allotted a research grant of $3,475.00 for a study of the effects of bacteria on petroleum and natural gas. The grant was made available from funds provided by the Kansas Industrial Development Commission.

Dr. Weldon N. Baker has replaced Dr. F. E. Jacobs as professor of chemistry at Kansas State College, Emporia. Dr. Jacobs has resigned to accept a position at Drake University, Des Moines, Iowa. Dr. Baker, a graduate of Morningside College, the University of Iowa, and Columbia University, has been since 1934 a research chemist with the United States Rubber Co. at Watertown, Conn.

Open house for the inspection of the new laboratories of the Snyder Memorial Research Foundation, Winfield, was held on November 23. The Foundation, devoted to the study and research of medical problems, is directed by Miss Leitha Bunch, formerly instructor in biochemistry at the University of Kansas. Professor Lawrence Oncley, formerly of the department of chemistry, Southwestern University, Winfield, began work for the Foundation on November first.

The office of the director of the National Park Service, during the war years located at Chicago, has been returned to Washington. All correspondence to the Service should now be addressed to Washington 25, D. C.

We regret to announce the death of Albert E. Shirling, a member of the Academy and for over forty years a widely known teacher and naturalist of Kansas City. Mr. Shirling, a graduate of Missouri State Teachers College, Warrensburg, and the University of Kansas, died on October 18, 1947, after returning from a vacation trip spent in Colorado. Born 72 years ago, Mr. Shirling had taught in Kansas City schools since 1905, and published many nature studies, chiefly as a result of his observations in Swope Park in the Kansas City *Star*. His paper on "The Age of Needle Leaves" appearing in the September, 1946, issue attracted wide attention.

Recent additions to the staff of Fort Hays Kansas State College, Hays, include Ferrel Bronson, instructor in biology; Gerald Tomonck, instructor in biology; Mrs. Ferrell Bronson, instructor in chemistry; Dr. Ivan Birrer, instructor in psychology; and E. C. Almquist, instructor in photography.

Dr. D. C. Warren, nationally known geneticist and professor of poultry husbandry at Kansas State College, Manhattan, since 1923, has resigned his position to accept a similar one at Purdue University.

Mr. W. L. Hoyle, formerly of Fort Hays Kansas State College is now instructor of biology at Southern Methodist University, Dallas, Texas. Mr. Hoyle also manages a pest control business with headquarters at Dallas.

Dr. John Breukelman has resigned his position as acting dean of the graduate division, Kansas State College, Emporia, in order to devote his entire time to his duties as professor of biology.

Dr. and Mrs. T. D. A. Cockerell are now living in San Diego, California, after spending the summer at Boulder, Colorado. Their many friends will be glad to know that Dr. Cockerell is now recovered after an illness which necessitated his stay in the hospital for six weeks.

Merle E. Brooks and Robert M. Hankins have been appointed instructors in biological science, Kansas State Teachers College, Emporia. Both Mr. Brooks and Mr. Hankins are graduates of Emporia.

The Kansas Industrial Development Commission has made a grant of $15,000 to Wichita Municipal University for the construction of a wind tunnel for the determination of aerodynamic qualities of planes. The Board of Regents of Wichita University has voted funds to match the grant awarded by the Commission to hasten the early completion of the project.

William J. Johnson, a graduate assistant this past year at Kansas State College, Manhattan, is now professor of chemistry at Tabor College, Hillsboro. Mr. Harold Regier, superintendent of schools at Hillsboro, served as instructor in chemistry and biology at Tabor this past summer while Professor S. L. Lowen, of the biology department, was struggling with the building program at Tabor in an effort to solve faculty and student housing problems.

A Saline Habitat Group, a life-size model of western Kansas plants and animals of 1865, is now under construction at Fort Hays Kansas State College, Hays. The group is being constructed by William Eastman, a graduate student in zoology, under the direction of George F. Sternberg, curator of the museum.

W. C. Rhoades, who received his master's degree from Okla-

homa Agricultural and Mechanical College this past June, has become a graduate assistant in the entomology department, Kansas State College, Manhattan. The department of entomology at Manhattan has also appointed Howard W. Smith of the University of New Hampshire to a research fellowship on insecticides and fungicides sponsored by the Sharples Chemical Company.

Dr. Charles E. Burt of the Quivera Specialties Company, Topeka, Dr. Harold K. Gloyd and Mr. T. I. Wright of the Chicago Academy of Science Museum, and Mr. Paul Anderson, of Independence, Missouri, took part this past summer in an extensive rattlesnake hunt near Pierre, South Dakota. The purpose of the hunt was to obtain specimens and to observe these famed snakes in their natural habitat.

Recent additions to the staff of the University of Wichita Foundation for Industrial Research include the following:

William H. Pierpont, a recent graduate of Wichita University, as a research fellow in chemistry.

R. D. High, a recent graduate of the College of Puget Sound, as a research fellow in petroleum geology.

Arthur C. Risser, a graduate of Grinnel College and a former student at Yale and Minnesota Universities, as industrial designer.

LaRue W. Wangerin, a graduate of Kansas State College, Manhattan, as research engineer.

A. M. Lennie, a graduate of the University of Michigan, as industrial consultant.

In addition to its full-time staff members and a number of Wichita University faculty members who participate in the work of the Foundation on a part-time basis, the Foundation is now giving part-time employment to fourteen students who serve as laboratory, shop, and clerical assistants.

Bethany College, Lindsborg, announces the appointment of William Horblit, a graduate of Colorado School of Mines, as instructor in chemistry, and Paul Prior, a graduate of Iowa State College, as instructor in biology.

The Journal of the Colorado Wyoming Academy of Science for June, 1946, makes its appearance after a lapse in publication since April, 1942. The current issue, edited by Professor Don B. Gould of Colorado College, includes a list of officers of the Academy, a membership list and abstracts of the papers presented at Academy meetings for the years 1944 and 1945. Among the activities of our sister Academy are the announcements of annual research awards of fifty dollars to a student in an institution affiliated with the Academy and a list of Academy sections which include the fields of anthropology, bacteriology, chemistry, education, physics, plant science, psychology, social sciences and zoology.

We also note with interest that another sister academy, the California Academy of Science, announces a membership of 1060 persons for the year ending Dec. 31, 1946; the first time in 12 years that the Academy has had a total membership in excess of 1000. Among the four honorary members elected by the California Academy this past year was Dr. Alexander Wetmore, secretary of the Smithsonian Institution, and since 1945, an honorary member of the Kansas Academy of Science.

In the September issue (p. 120), the editor called attention to the reports of President Truman's Scientific Research Board which were then in the process of publication. All four remaining volumes of the five volume set *Science and the Public Policy* have now appeared. The specific titles and the cost of each volume is listed below but it can again be stated that these volumes are of primary importance to the scientific profession. Volume four particularly, *Manpower for Research,* should have the serious attention of every scientist, of every employer of scientists, and of every administrator where science instruction is given. The editor urges that copies of this report particularly be secured and studied. The complete set of reports includes:

Vol. 1, *Science and Public Policy—A Program for the Nation,* 73 pages, August 27, 1947, 20 cents.

Vol. 2, *The Federal Research Program,* 318 pages, September 27, 1947, 55 cents.

Vol. 3, *Administration for Research,* 324 pages, October 4, 1947, 55 cents.

Vol. 4, *Manpower for Research,* 166 pages, October 11, 1947, 35 cents.

Vol. 5, *The Nation's Medical Research,* 118 pages, October 18, 1947, 25 cents.

All five volumes are by John R. Steelman and copies may be secured for the price indicated by addressing the Supt. of Documents, Government Printing Office, Washington, 25, D. C.

Dr. Robert M. Dreyer, department of geology, University of Kansas, has received a second grant from the Geological Society of America for the investigation of the origin of ore minerals. The total grant for the research project, which is a cooperative effort with Northwestern University, amounts to more than $13,000. Part of the work will be conducted in the field next summer in Arizona and New Mexico. Dr. Dreyer will also direct a research project on Kansas coals sponsored by the Pittsburg & Midway and the Sinclair Coal Companies.

A good response has been received to the call for membership in the newly organized Kansas Psychological Association which is an outgrowth of the Psychology Section of the Kansas Academy of Science and which will be affiliated with the Academy. Applications are in the process of being reviewed by Dr. A. C. Voth, Topeka, and Dr. Paul G. Murphy, Pittsburg, who were designated to serve as an organization committee for the new group, and applicants will be notified shortly of the action

taken. The constitution adopted at the Lawrence meeting last spring provides for two classes of members, fellows and associates, as well as affiliates. All those whose applications were received before November 15 will be listed as charter members or charter affiliates of the organization; however, anyone who is interested is cordially invited to apply for membership at any time. Inquiries should be addressed to Paul G. Murphy, Kansas State Teachers College, Pittsburg, Kansas.

Dr. W. H. Mikesell, formerly head of the psychology department at the University of Wichita and more recently clinical psychologist with the Veterans' Administration, has taken a position as professor of psychology at Washburn University, Topeka.

As a part of the lower division requirements recently set up at Fort Hays Kansas State College a new course in basic biology is being offered. Lower division students are required to take the course unless exempted on the basis of a preliminary examination. While one of the goals of this course is to provide a background for further study in the field, it is not "basic" in that it is a prerequisite for such study, but aims rather to satisfy the needs and desires of the student to know more about himself and his relation to the living world around him. Dr. Harry V. Truman, a graduate of Ohio Wesleyan University and the University of Wisconsin, was added to the staff to set up the new course along the lines laid out by the undergraduate committee of the college. He is assisted by Dr. Leon W. Hepner, graduate of the University of Kansas, and Gerald Tomanek, graduate of Fort Hays Kansas State College, who divide their time between the basic biology course and their respective fields of entomology and zoology.

Members of the staff of the chemistry department of Kansas State College, Manhattan, were hosts to the members of the chemistry department staff of the University of Kansas on Saturday, December 13th. The visitors inspected the chemical laboratories and equipment at Kansas State, and were entertained at a noon luncheon followed by a seminar meeting at which the work under progress at Kansas State was described by various members of the staff. Some thirty members of the combined staffs took part in the all day conference.

The secret of culture is to learn that a few great points steadily reappear alike in the poverty of the obscurest farm and in the miscellany of metropolitan life, and that these few are alone to be regarded,—the escape from all false ties; courage to be what we are; and love of what is simple and beautiful; independence, and cheerful relation, these are the essentials,—these, and the wish to serve—to add somewhat to the well-being of men.—Ralph Waldo Emerson, *The Conduct of Life,* 1829.

Survey of the Fossil Vertebrates of Kansas
Part V: The Mammals

(Continued from the September Issue)

H. H. LANE
University of Kansas

Order Carnivora:

The mammals constituting the Order Carnivora vary in size from small to very large and are mostly adapted to a diet of flesh, which they obtain by killing plant-eaters, although some are carrion-feeders, and others are fish-eaters, omnivorous, or even largely vegetarian. They generally have long, pointed "canine" teeth for piercing and holding struggling prey. The fourth upper premolar and the first lower molar are generally of a form adapted, like a pair of shears, for slicing the meat which they swallow in chunks without chewing. The alimentary tract is simple and relatively short. The brain is large, with the cerebral hemispheres convoluted. Yet despite all their variation in size and habits, the "beasts of prey" constitute a natural assemblage quite distinct from all other mammals at the present time. In the early Tertiary, however, their generalized representatives are sometimes difficult to distinguish from the contemporary hoofed mammals. Today they are provided with strong claws that constitute formidable weapons.

Until recently it has been customary to recognize three sub-orders of the carnivores—(1) the *Creodonta,* long totally extinct; (2) the *Fissipedia;* and (3) the *Pinnipedia.* Now, Gregory and Hellman have instead proposed a series of five "infraorders," four of which represent the old group of the creodonts, while the fifth, *Infraorder Eucreodi,* includes one family (*Miacidae*) of the creodonts and *both* the old sub-orders Fissipedia and Pinnipedia. No creodonts are known from Kansas. A classification of the Eucreodi, modified for our purpose, is as follows:

CLASS MAMMALIA
- INFRAORDER EUCREODI (Matthew)
  - *Superfamily Aeluroidea* Flower
    - Family Miacidae (all extinct; ancestral to later carnivores)
    - Family Viverridae, civets, genets, etc. (non-American)
    - Family Herpestidae, mongoose, etc. (non-American)
    - Family Hyaenidae, hyenas (non-American)
    - Family Felidae, cats
  - *Superfamily Galeoidea nobis*
    - Family Mustelidae, weasels, mink, skunks, otter, etc.
  - *Superfamily Arctoidea* Flower (*in part*)
    - Family Canidae, wolves, foxes, jackals, etc.
    - Family Procyonidae, raccoons, cacomistle, coati-mundi, etc.
    - Family Ursidae, bears.

The Viverridae, the civets, genets, etc., include *no American forms.* The same is true of the Herpestidae, mongooses and their kin, and the Hyaenidae, the hyenas. Hence they will receive no further consideration here. The old suborder, Pinnipedia, including the seals and sealions, likewise has no representatives in Kansas, either living or fossil.

Family Felidae:

This is the family of the cats in the broad sense of that term. In both structure and habits the cats are very highly specialized. They feed in the wild almost exclusively upon warm-blooded animals killed by themselves; a few are fish-eaters. They are mostly solitary, or at most associate in pairs or family groups, never in packs like the dogs, but stalk and spring upon their unsuspecting victims. If not successful in the first attempt, they rarely pursue the prey more than a few leaps farther. They are mostly nocturnal and more or less arboreal, except in the case of some of the largest species, such as the lion and tiger. They vary in size from small to large, and are well-muscled, neat and trim in form and habit. The face is usually short in comparison with the rest of the well-rounded head. The moderately long limbs terminate in digitigrade feet usually with five toes in front and four behind, all provided with long, sharp-pointed, generally retractile claws. The carnassial teeth are large, sharp-edged shears, without accessory cusps on the lower ones. Crushing molars are absent. The dental formula varies somewhat in the three subfamilies, in the *Felinae* being: I-3/3 C-1/1 P-3/2 M-1/1=30; reduced in the Lynxes to 28 by the loss of a premolar. In the Sabre-tooth Cats, subfamily *Machairodontinae,* the formula is: I-3/3-2 C-1/1 P-2/2-1 M-1/1=28 or 26, the lower incisors and premolars being variable in number. In this latter group the most remarkable or striking peculiarity lies in the immense, recurved and flattened dagger-like upper canines, the edges of which are finely serrate; broad antero-posteriorly, but thin and transversely compressed. These "sabres" were probably used in striking like a snake strikes with its fangs. When the mouth was closed the upper canines projected, in some instances, *e.g.,* in *Smilodon,* several inches below the lower jaw, enough to inflict terrible wounds without opening the mouth. In some of the Oligocene sabre-tooths like *Hoplophoneus* (Fig. 1), for example, the projecting ends of the sabres were completely protected by huge flanges of bone hanging downward from the jaw proper, and hence the animal was compelled to open the mouth widely in strik-

ing. In the subfamily *Nimravinae* the dental formula is: I-3/3 C-1/1 P-3-4/2-3 M-1/2=36 or 32. The succession of genera included in this group underwent such great changes in structure in the course of their long career, that it is very difficult to give a brief characterization of the subfamily. Cope called them the "False Sabre-tooths," implying that their resemblances to the "true" sabre-tooth cats was the result as much of parallelism or convergence as of kinship. The upper canine is relatively much larger than in the true cats, while the lower canine is small, and there is a small but distinct flange on the lower jaw for the protection of the distal end of the upper canine or "sabre". In *Nimravus* itself the jaw lacks anything more than a mere hint of a flange. To this subfamily two genera from Kansas described by Hibbard are referable, namely,

FIG. 1.—A diorama in Dyche Museum of Vertebrate Paleontology showing the sabre-toothed cat, Hoplophoneus, crouched to spring upon a little camel, Poebrotherium, which was about the size of a sheep. Diorama made by Bernard Frazer under the author's direction.

Pratifelis and *Adelphailurus,* which Simpson considers to be synonyms of *Pseudaelurus.* Of the subfamily *Machairodontinae,* Kansas has yielded examples of *Machairodus* (?*Heterofelis*) and *Smilodon;* the subfamily *Felinae* is represented here by the genus *Felis* only.

Adelphailurus (?*Pseudaelurus*) *kansensis* Hibbard (type: KUMVP, No. 3462) was based on a skull with a practically complete dentition from the Middle Pliocene, Ogallala formation, Edson beds, of Sherman County. Its dental formula is: I-3/3 C-1/1 P-3/2 M-1/1=30; probably, however, the second upper premolar is variable, being either present or absent. The canines are well developed but have a slightly serrated cutting edge on the posterior side only. Near the antero-internal edge there is a deep groove that extends

nearly to the tip of the tooth. This was a cat with a broad, high face. The strong, deeply-rooted incisors are in a straight line, and the third (outer) one is larger than that of a large puma (cougar, or mountain lion). It is deeply grooved on its postero-lateral surface for the reception of the lower canine. The slightly convex anterior surface of the upper canine passes into the lateral face of the tooth through a decided convexity, which ends at the posterior cutting edge. The lingual side of the canine is flat except for a deep groove close to and parallel to the anterior margin, which forms a sharp shearing edge where it makes contact with the lower canine. The groove, deepest near the base of the tooth, becomes shallower as it approaches the point of the canine, and disappears about 17 mm. from the tip. Hibbard contrasts *Adelphailurus* with *Pseudaelurus* and *Metailurus,* two previously known nimravine genera, and notes several characters in the teeth and jaw that separate it from the one or the other, but seemingly place it in an evolutionary series between *Pseudaelurus* and *Felis.*

From the Middle Pliocene, Ogallala formation, "Lost Quarry," Wallace County, Hibbard has described another nimravine under the name of *Pratifelis martini* (type. KUMVP, No. 3156). Its dental formula is: I-3/3 C-1/1 P-2?/2 M-1/1=28. This species has a very light jaw for so heavy a dentition as it has. It was certainly a short-faced cat with a large upper molar, but with the premolars (except the upper carnassial) reduced. *Pratifelis* presents very primitive characters in its third and fourth lower premolars, which, with other primitive characters in the dentition, point to a direct development from *Nimravus* rather than from *Pseudaelurus.* It differs too from *Metailurus* in important tooth characters. *Pratifelis* was probably larger than the living puma (*Felis concolor*).

An undetermined species of felid from the Pleistocene Interglacial, Borchers fauna, has been recorded in the literature as *Felis?* and as *Pseudaelurus* sp. The latter generic reference would certainly seem to be erroneous, since that genus is not otherwise known since Lower Pliocene. This specimen (KUMVP, No. 6472) consists of the lower right carnassial only of some large cat, perhaps slightly smaller than a puma, so that very little can be stated positively about it.

The subfamily *Machairodontinae* has its oldest recorded species from Kansas in *Machairodus* (or *?Heterofelis*) *crassidens* Cragin from the lower Middle Miocene, near Long Island, Phillips County —a horizon a little older than the Edson beds. This genus has the

dental formula: I-3/3 C-1/1 P-2-1/2 M-1/1=28 or 26. The upper carnassial generally has the three main cusps on the blade and the fourth accessory cusp near its anterior end on the lingual side. The lower carnassial is simpler and generally lacks a heel. The canines are long with a serrated posterior margin. This is mostly an Old World genus, occurring in the Miocene and Pliocene of Asia, the Miocene to Pleistocene of Europe, the Pliocene and Pleistocene of Africa, but it is also found in the Pliocene of North America. Some species of *Machairodus* were very large, rivaling the largest tigers of today. As the name *crassidens* indicates, Cragin's species has very heavy teeth and was probably a large cat. Another species recorded from Long Island, Phillips County, is *Machairodus maximus* Scott, about which we can say little except that it also was a very large cat.

From the Middle Pliocene, Ogallala formation, Edson beds, Sherman County, Hibbard has reported a species as *Machairodus*

FIG. 2.—A diorama in Dyche Museum showing an elephant caught in an asphalt pit and soon to be attacked by the sabre-toothed cat, Smilodon. Diorama made by Bernard Frazer under the author's direction.

cf. *catocopis* Cope. No details are given. From the Rexroad fauna of Meade County, the same author reports a fragmentary specimen (KUMVP, No. 3917) as *Machairodus* sp., which is to date the only evidence of a sabre-toothed cat from this fauna. It is referred to *Machairodus* rather than to *Ischyrosmilus* since it is not sufficiently advanced or specialized for the latter genus.

The best known of all the sabre-toothed cats is the genus *Smilodon* (Fig. 2), an undetermined species of which is recorded from the Pleistocene, Big Springs Ranch, Cragin quarry, in Meade County, on the basis of the fragmentary remains of a young individual (KUMVP, No. 3657). Other fragmentary specimens of *Smilodon* have also been recorded from the Pleistocene of McPherson and Douglas Counties, and from the XI Ranch of Meade County.

Smilodon is a genus of sabre-toother cats so important and so widely distributed as to be worthy of a more extended notice here. Of one species, *S. californicus,* over 2500 specimens, several of them complete skeletons, have been taken from the Rancho La Brea asphalt pits near Los Angeles, California. Several species of the genus ranged in the Pleistocene over nearly all of the United States from Pennsylvania to California and Mexico, some even reaching Brazil and Argentina. One notable feature was the relatively small size of the brain, indicating that it was stupid in comparison with living cats. ·It was approximately the size of the African lion, though with shorter legs and a very short, lynx-like tail. Its upper canine, about seven to nine inches ling, is an immense, curved, sabre-like tooth with the cutting edge serrated. The chin is flat and there is only a small flange on the lower jaw, generally too small to afford any protection to the sabre, which projects below it for several inches. The heavy neck-vertebrae indicate the presence of great muscles that moved the head in the act of stabbing. The body as a whole is stout, even massive, relatively heavier than that of a Bengal tiger. The front legs are much heavier than the hind ones, though all four are comparatively short, and give evidence of great muscular power. All in all, the picture is one of a very large and powerful cat capable of striking down the largest ungulates, whose blood probably constituted the bulk of its food. *Smilodon* is a genus apparently wholly confined to America where it must have been a veritable scourge to the herds of large herbivores that grazed in the regions where it occurred.

Of the "true" cats of the genus *Felis,* the earliest fossil species from Kansas is *Felis lacustris* Gazin from the Rexroad fauna of Meade County. The type of this species (U. S. Nat. Mus., No. 12611) was described by Dr. C. Louis Gazin, of the U. S. National Museum, from the Hagerman lake beds, near Hagerman, Idaho. It represents an animal closely resembling the puma (*Felis concolor*), but somewhat smaller than an average individual of that

species, though apparently larger and more robust than the lynx (*Lynx canadensis*). It is distinguished from the living puma by the relative proportions of the teeth and by the shape of the anterior part of the lower jaw, which does not project downward below the lower border of the maxilla. The cheek-teeth are slender, the premolars being relatively narrow anteriorly, while the lower carnassial is small. The Kansas specimen (KUMVP, No. 4665) consists of a crushed skull and the two halves of the lower jaw, and is indistinguishable from Gazin's species.

From the same locality in the Rexroad, Hibbard reports "a cat as large as *Felis atrox*," which was considerably larger than a large African lion. The Kansas specimen (KUMVP, No. 3918) is only a single canine tooth.

From the Pleistocene near Newton, Harvey County, there is the record of a cat (*Felis* cf. *atrox* Leidy) about a fourth larger than a large male African lion with which it was directly compared. This specimen (KUMVP, No. 4646) very probably represents a "lion" that was apparently widespread over the United States within the latter part of the "Ice Age." A species apparently equally large, but undetermined, has been recorded from the Pleistocene, Big Springs Ranch, Cragin quarry, in Meade County.

Hibbard also records a cat as *Felis* cf. *imperialis* Leidy from the same Big Springs Ranch site. Leidy's species is a large lion-like form somewhat smaller, but otherwise apparently quite similar to *Felis atrox*. The differences may have been due to sex. Again from the same site Hibbard notes a puma as *Felis* cf. *oregonensis* Rafinesque. *Felis oregonensis,* with five subspecies, is found today throughout California along the Pacific coast to British Columbia, and inland through Alberta, Idaho and Montana into North Dakota, and southward through Colorado and Utah to New Mexico, Arizona and western Texas into Mexico. It may recently have ranged into Kansas and Oklahoma. In size it varies from 78 to 102 inches in total length, and weighs from 150 to 220 pounds. This is the common puma, mountain lion, or cougar, of our western states. The dental formula is: I-3/3 C-1/1 P-3/2 M-1/1=30. This is a beautiful dull yellowish brown or tawny cat with lighter underparts that is familiar to every one who has visited a zoölogical park.

SUPERFAMILY GALEOIDEA

Family Mustelidae:

The *Family Mustelidae,* until recently, has been referred to the Arctoidea, but the study of Gregory and Hellman has shown that

it is more closely allied to, probably a derivative of, the *Viverridae*, but not so closely related to justify assignment to the Superfamily Aeluroidea. These authors therefore have erected for it a new superfamily allocated to a position between the Aeluroidea and the Arctoidea, which they term the Superfamily Musteloidea. However, this name is objectionable on the ground that it is a bastard coinage with a Latin root and a Greek suffix. The same remark holds in connection with Simpson's terms Feloidea and Canoidea, for Aeluroidea and Arctoidea respectively, with the additional objection that the latter names have been in general use for fifty years, and therefore are not to be lightly discarded or replaced. We therefore have retained Aeluroidea and Arctoidea, and suggest Galeoidea for the superfamily name Musteloidea of Gregory and Hellman. *Galeoidea* is coined from the Greek *Gale,* a weasel, and *-oidea,* like.

The family *Mustelidae* comprises the minks, weasels, martens, otters, skunks, badgers and wolverines. They are small to medium, or a few even large, in size, slender to stout of body, with short limbs. The feet are five-toed, the gait digitigrade (*i.e.,* walking on the toes), or almost plantigrade in some instances. Typically with scent-glands, the secretions from which vary from a not unpleasing, somewhat musky odor to the highly irritating and very unpleasant product of the skunks. The premolars and molars are of the shearing and crushing types, with the carnassials well developed. They are terrestrial, arboreal, semi-aquatic or fossorial in habit, and are usually bold, blood-thirsty killers, often attacking and overcoming prey much larger than themselves. The fur is in many cases of high commercial value. The dental formula is: I-3/3 C-1/1 P-4/4 M-1/2=38; or I-3/3 C-1/1 P-3/3 M-1/2=34; or, in the otters, I-3/3 C-1/1 P-4/3 M-1/2=36, reaching the extreme of reduction in the Seat Otter of I-3/2 C-1/1 P-4/3 M-1/2=32. At least eight genera are known as fossils from Kansas.

From the Middle Pliocene, Ogallala formation, Edson beds, Sherman County, there have been described two genera, the first of which is *Plesiogale marshalli* (Martin) (type: KUMVP, No. 3464), collected and described by the late H. T. Martin from a site fifteen miles south of the small railroad town of Edson, Sherman County. In this form the lower jaw and skull appear to have been stoutly built, and indicate an animal of great strength; the dentition, the size and shape of the jaw and skull, and the general make-up suggest its close relationship to the wolverine (Fig. 3). "As in the wolverine, the long, rather slender condyle [*i.e.,* articulating pro-

cess] of the lower jaw locks firmly in place in the glenoid fossa [*i.e.*, the groove in the temporal bone in which the condyle moves], and is held there by a strong backward curving glenoid process, so that it is impossible to remove the [lower] jaws from the skull except by breaking them apart at the symphysis [*i.e.*, the union of the two halves or rami], and sliding them out sideways, exactly as one must do with the wolverine jaw. The symphysis of the jaw is both long and wide, and deeply sculptured. The masseteric fossa [*i.e.*, the area for the insertion of the muscles which close the jaw] is deep and wide" (Martin). The canine is of large size and flattened laterally. "It measures one-fourth larger than the canine of *Aelurodon* [see below] and is so large as to appear out of proportion to the other teeth" (Martin). The fourth upper premolar (carnas-

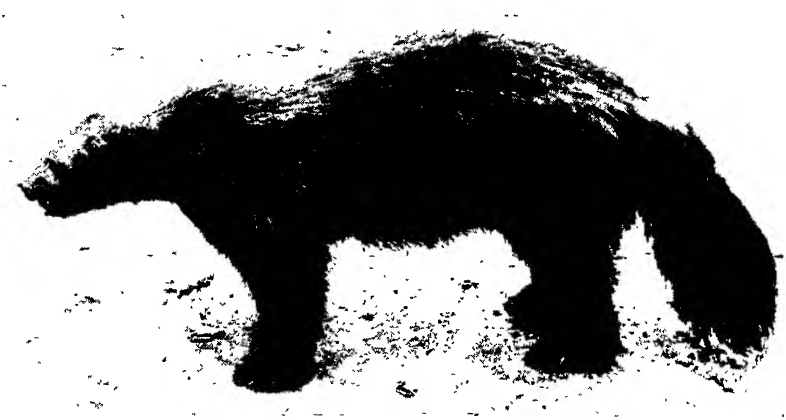


FIG. 3.—Wolverene. Photograph from life by W. W. Dalquest.

sial) is a strong, deep-rooted tooth with a relatively short shear. The first upper molar has a large crushing heel nearly twice as large as that of the wolverine. All in all, *Plesiogale marshalli* must have been a formidable carnivore, probably with habits much the same as those of the living wolverine, or glutton, which ranges over North America from the Arctic Ocean into our northern states. It is the largest mustelid, being almost as large as a small Black Bear.

The second mustelid genus reported from the Edson beds is *Martinogale alveodens* Hall (type: KUMVP, No. 3473), first found at a site some eighteen miles southeast of Goodland, Sherman County, by the late H. T. Martin, for whom the genus was named. Its dental formula is: I-3/3 C-1/1 P-3/3 M-1/2=34. This was an animal about the size of the ermine (*Mustela cicognani*) which in

the male reaches a length of eleven inches, in the female, nine inches, from snout to end of the tail vertebrae, and occurs over most of North America. *Martinogale alveodens* may be described as a small, slender, long bodied, short legged weasel, probably terrestrial and blood-thirsty like its recent confreres. Its other distinguishing characters are too technical for mention here. A second specimen (KUMVP, No. 3833) was taken by Dr. E. H. Taylor and Dr. David Dunkle from the same horizon in Sherman County, which shows only minor differences from the type specimen, probably sex differences, "since sexual differences in size and to a lesser degree in structure are markedly evident in the living representatives of this group" (Dunkle).

Mudge collected a right ramus of the lower jaw of *Brachy-*

FIG. 4.—Fisher, closely resembling the Marten. Photograph from life by W. W. Dalquest.

psalis pachycephalus Cope (Peabody Museum, Yale University, No. 12803) near Ellis, Ellis County, Kansas, in the Ogallala formation, Middle Pliocene. This specimen of a mustelid has characters intermediate between certain other species of the genus, but its modifications, according to Thorpe, are much less extreme than in either of the others.

From the Rexroad fauna of Meade County, four species of mustelids have been recorded to date. The first of these is *Trigonictis kansasensis* Hibbard (type: KUMVP, No. 4604). The dental formula is: I-3/3 C-1/1 P-3?/3 M-1/2=34, or possibly only 32. This species is distinguishable from all other known fossil and recent

mustelids by the structure of the triangular upper carnassial, which is too technical in nature for description here. It was an animal probably about the size of the living Marten (*Martes americana*) which is a little smaller than a house cat, *i.e.,* with a total length of 23 to 25 inches (cf. Fig. 4).

A second genus and species from the Rexroad fauna is known as *Brachyprotoma breviramus* Hibbard (type: KUMVP, No. 4609). This is the smallest known species of this genus and is distinguished by the smaller dimensions of the lower carnassial and the greater depth of the lower jaw. It was a small weasel-like carnivore, but is too imperfectly known for further description here.

A third species from the Rexroad fauna is the common Badger, *Taxidea taxus* (Schrebel), which is well known to Kansans, though it is not so common as formerly. It is an animal of stout build, short legs, large strong claws adapted to digging the familiar "badger holes" or burrows in which it dens. It occurs over central North America from Saskatchewan southward. The dental formula is: I-3/3 C-1/1 P-3/3 M-1/2=34. It reaches a length of 28 to 30 inches, and its skin is so loosely attached to its body that it is popularly thought to be able "to turn over within its skin"—which, of course, it cannot do! Its face is camouflaged by whitish stripes and patches on the head that give it the semblance of a mask. It weighs, when fully grown, from 13 to 23 pounds. Two specimens are known from the Rexroad fauna (KUMVP, No. 3916 and 4605). The species is also recorded from the Pleistocene, Jones fauna, of Meade County as well as from the Upper Kingsdown (Pleistocene) of the Pyle Ranch, Clark County.

The fourth species from the Rexroad fauna of Meade County is *Spilogale rexroadi* Hibbard (type: KUMVP, No. 4596; referred material, No. 4573 and No. 4578). This is a small skunk belonging to the same genus as the little Spotted Skunk, or "Hydrophobia Cat", now living in Kansas, which in the male reaches a length of 19 to 22½ inches, and in the female 17½ to 21½ inches. However, *S. rexroadi* was smaller in size than the living species and is distinguished otherwise by peculiarities in the form of its teeth. Another species, recorded as *Spilogale* cf. *leucoparia* Merriam, is from the Pleistocene Interglacial, Borchers fauna, of Meade County. This species reaches a length of only 16 inches, and occurs today in the "arid region of western Texas and southern New Mexico; west to central Arizona; and south over the eastern side of the Mexican table-land to Hidalgo" (Howell).

From the Pleistocene, Jones fauna, of Meade County, there has been recorded a large skunk of the genus and species *Mephitis mesomelas* Gray. This is a large striped skunk living in the central states from western Indiana, Illinois, Iowa, Nebraska and Colorado southward through Kansas, Missouri and Oklahoma into Louisiana, Texas, eastern New Mexico and southward into Mexico. It is an animal two feet or a little more in total length, black in color with a narrow white stripe along the mid-line of the head from the nose to the nape, a broader spot or band thence to the shoulders, where it usually splits and passes as two white stripes to the base of the tail, one on each side of the body. There is nothing to distinguish the fossil specimen from the living species. A second specimen of the same species, but assigned to the subspecies *M. m. varians* (Gray) has been recorded from the Pleistocene of Barton County. This is the subspecies living in Kansas today.

SUPERFAMILY ARCTOIDEA Flower

Family Canidae:

The dog family, *Canidae,* is the most widely distributed of all the families of carnivores, being found on every continent, though the Australian Dingo, the only representative of the *order* in that continent, was probably brought there originally by man. Not only the multitudinous variety of domestic dogs, but wolves, foxes, jackals, and some other less familiar forms make up this family, all members of which are terrestrial, none arboreal, aquatic, or truly burrowing, though foxes and coyotes have holes for dens. Many canids are solitary, while others hunt in packs, and all have remarkable speed and endurance, depending on running down the fleeing prey. In accordance with this method of securing food, they are generally bold and savage in disposition, though some are capable of domestication, exhibit a high degree of intelligence, and are loyal to their human masters. The dental formula is: I-3/3 C-1/1 P-4/4 M-2/2=42. The incisors are sharp-edged nipping teeth; the canines —so-called because they are characteristically "dog" teeth—are strong though variable in length, stoutness, and sharpness of point, generally most effective instruments in seizing and holding the prey. The last upper premolar has a blade of two external laterally compressed shearing cusps, and a small internal cusp near the anterior end of the blade carried on a separate root. This tooth and the first lower molar constitute the so-called "carnassials" found in most carnivores. The lower carnassial (or first molar) has an anterior shearing blade of two laterally compressed, sharp-edged cusps and

the vestige of a third, while behind these cusps there is a low "heel", which may have the form either of a slightly concave "basin", or of a small accessory trenchant cusp. The three upper molars and the second and third lower ones are low-crowned and rooted, for crushing bones. The face and jaws are elongate; the brain-case relatively large, and the orbits of the eyes widely open behind. The neck is short, the body usually long, while the tail varies and may or may not be bushy. The legs are short to long and the feet are provided with blunt, non-retractile claws. The thumb is vestigial and the big toe absent.

The genus *Aelurodon* is sometimes, though improperly, called the "hyena-dog", for it is not in any sense a "connecting link" between the dog and the hyena, but represents, rather, a side-branch of the true dog-line. It is known by complete skeletons from the Upper Miocene and Lower Pliocene. There are several described species which differ much in size, some being as large as the Gray Wolf. It had in fact much the proportions and many of the tooth characters of that type of living wolf, but may be easily distinguished by the presence of an extra cusp at the anterior end of the upper carnassial, in which respect it resembles the hyena and cats, rather than the true dogs. It had shorter and much heavier jaws than the Gray Wolf, but was probably similar to that animal in habits. Scott remarks of *Aelurodon* that:

"In the skeleton, the structure of the body, limbs and feet it is very modern, but the skull is short and massive. The premolars are so thick and hyena-like that this genus has mistakenly been regarded as actually ancestral to the hyena family, whereas the skull and skeleton are typically dog-like. The name of the genus, which means "cat-tooth", is taken from the upper sectorial [carnassial], which, as in the cats, has no internal cusp, but a third root indicates its former presence. The skull is short and massive and looks somewhat like that of a bear, because of the deep descent at the forehead from the cranium to the face."

Two species, *Aelurodon saevus* Leidy and *A. wheelerianus* Cope, have been reported from the "Upper Miocene and Lower Pliocene, Republican River" of Kansas, but I have not had access to the original citations. The same remark applies to *Tomarctus* sp. and *Pliocyon meandrinus* Hatcher, two still more primitive canids, reported from both "the Republican River" and the "Smoky Hill River" of Kansas.

From the Middle Pliocene, Ogallala formation, Edson beds, of

Sherman County, there have been recovered two genera of primitive canids. The first of these was described by Hibbard under the name of *Leptocyon shermanensis* (type: KUMVP, No. 3608), and represents an animal rather like a large fox but distinct in both size and dentition from any form hitherto described and may warrant recognition as a new genus. The jaw is long, slender and tapering toward the anterior end. The incisor teeth are crowded together, while the canine is long and sharply pointed. The numerous other distinguishing characters are technical.

The second species of canid from the Middle Pliocene, Edson beds, of Sherman County, is now known as *Borophagus cyonoides* (Martin) (type: KUMVP, No. 3468). This was a formidable and curious-looking carnivore like a wolf in some respects, but like a hyena in others. It had a high bulging forehead backed by a comparatively small brain-case, the whole skull being fully eight inches long. The facial region was relatively short, while the teeth were massive, becoming well-worn with age, and the jaws exceptionally stout. The wide cheek arches (zygomatic) for the origin of powerful muscles for closing the jaws, as well as the high sagittal crest (for the same function), are adaptations to the bone-crushing habit, for seemingly this creature fed upon the leavings of other, more delicate-toothed carnivores. The skeleton otherwise is entirely wolf-like and is that of an animal about the size of a coyote, but with shorter legs. *Borophagus* is a representative of a group of hyena-like, surely carrion-feeding, dogs that were abundant in the Miocene and Pliocene of North America, but which, for some reason, became extinct without leaving descendants in later time. *Borophagus* may have been directly derived from *Aelurodon.*

From a Middle Pliocene deposit, Ogallala formation, in Seward County, Hibbard recovered a fossil canid which he described under the name of *Osteoborus progressus* (type: KUMVP, No. 6791). This is a large dog-like carnivore with an exceptionally large lower fourth premolar, larger in size but in form resembling the corresponding tooth in *Borophagus. O. progressus* has a much heavier jaw than had *Borophagus cyonoides,* and differs from other described species of its own genus in having the more heavily developed fourth premolar with no accessory cusps. The type is an old individual with well worn teeth.

From the Rexroad fauna, of Meade County, Hibbard records *Canis lepophagus* Johnston, represented by several fragmentary specimens (KUMVP, No. 3914, No. 4602, and No. 4603). This is

probably an ancestral coyote, and is smaller than the living *Canis latrans* (common Coyote). The greatest differences, in addition to size, in these two species are found in the more tapering jaw and in the teeth, —*C. lepophagus* in tooth pattern is slightly more primitive or generalized, but needed to make only very slight changes to become a coyote, *viz.*, a slight increase in size and the development of heavier teeth. Another specimen of dog (KUMVP, No. 3915), from the same site, is as large as *Canis latrans* but otherwise is indistinguishable from *C. lepophagus.*

Canis lupus occidentalis, the very large Gray Wolf, which, however, is sometimes almost black in color, living today in the forests of northwestern Canada, has been reported, according to O. P. Hay, from the Pleistocene, Twelve Mile Creek, of Logan County, and spring Creek, Meade County. Hay also reports another but undetermined *Canis* sp. from Logan County. Hibbard has recovered a *Canis* sp. from the Pleistocene Interglacial, Borchers fauna, of Meade County. From the same Borchers fauna, Hibbard also reports *Aenocyon dirus* (Leidy), the well-known extinct "Dire Wolf" that probably ranged all over North America in the late Pleistocene, and was probably very abundant, since over *three thousand* specimens of this form have been recovered from the Rancho La Brea asphalt pits near Los Angeles, California, alone. To judge from the manner of wear of its teeth, the Dire Wolf seems also to have had the habit of feeding to a large extent upon carrion and had massive teeth well fitted for crushing large bones. It varied considerably in size, in some cases reaching a size probably twice that of a large Gray Wolf. It had a disproportionately heavy head, relatively small brain, and slender limbs. It has also been recorded from the Upper Pleistocene of the XI Ranch in Meade County, and likewise was reported by Merriam from the Sheridan formation of Kansas.

The family *Procyonidae* includes the familiar raccoon, as well as the cacomistle, the kinkajou and a few other forms, typical of tropical America, of which only the first two are found within the United States, the Cacomistle now having the northern limits of its range from southern Texas to southern California, though it is said by Scott to have extended into Kansas in the Pleistocene. No fossil specimens of this form (genus *Bassariscus*) from Kansas are known to me, but Hibbard has described a species as *Bassariscus ogallalae* (type: KUMVP, No. 3749) from the Lower Pliocene, of the Feldt Ranch, in Keith County, Nebraska. There can scarcely be a doubt that it also lived in Kansas.

The Raccoon, however, occurs over most of North America up to the 50th parallel of latitude. It is familiar to most people as a robust bodied, rather short-legged, squat carnivore of considerable size—when fully grown about 30 inches long and weighing in exceptional cases up to nearly 50 pounds, although the average adult weight is much less, perhaps only 15 to 20 pounds. Its snout is rather long, slender and pointed, though the head is broad across the eyes. Its ears are large, erect, and conspicuous. The feet are five-toed with naked soles, the hind ones plantigrade, *i.e.*, with the heel resting squarely upon the ground when walking. The track of the hind foot greatly resembles that of a small barefoot boy. The fairly long tail is bushy and distinctly marked with six or seven blackish rings alternating with grayish bands. The dental formula is: I-3/3 C-1/1 P-4/4 M-2/2=40.

From the Rexroad fauna, of Meade County has been recorded a species of raccoon under the name *Procyon rexroadensis* Hibbard (type: KUMVP, No. 5522; referred material: No. 5523). This appears to have been a large raccoon which shows some resemblance to *Aelurus,* the Panda of the Himalaya Mountain region of Asia. It is distinct from all other known fossil raccoons as well as from the living species.

Family Ursidae:

Although the bears (*Family Ursidae*), including both the Black and the Grizzly, have lived in Kansas, apparently, within the past one or two centuries, no record of a fossil bear from this state has yet been made.

Order Rodentia:

The number of genera and species of living rodents exceeds by far that of all other mammals combined. Despite certain fundamental structural characters that render the identification of a mammal as a rodent, there are yet so many variations in size, form, anatomy and habits, that it is difficult to distribute them according to any simple plan. Among the most readily determined characteristics of this order are: (1) the relatively small size of most of its members; (2) the large, continuously growing, chisel-shaped incisor teeth; (3) the total absence of canine teeth; (4) the presence of a wide space (diastema) between the incisors and the cheek-teeth; and (5) the reduction in the number of the premolars, there being usually only one above and below on each side (two above in a few primitive genera), or they may be entirely lacking. The premolars, when present, and the molars may be short-crowned and rooted, or long-

crowned and rootless, growing in height continuously throughout life as fast as worn away at the top by use. The cheek-teeth (premolars and molars) all have similar crowns with various patterns (in different genera) in the arrangement of the enamel, but all adapted to grinding the food, which is mostly or entirely vegetable in nature.

The feet are plantigrade (i.e., the heel rests upon the ground in walking) or semiplantigrade, and generally have five digits (reduced to four in some cases), which are usually provided with claws, though in a few instances the claws resemble small hoofs. The lower jaw articulates with the skull in a groove (*glenoid fossa*) that is elongated antero-posteriorly, so that in chewing the jaw works with a forward and backward motion, quite unlike the side to side movement of a rabbit's jaw. The brain is primitive in that the cerebral hemispheres are without convolutions and do not extend backwards to cover any part of the cerebellum. There is also considerable variation in the organs of digestion and of reproduction.

The *Order Rodentia* is practically cosmopolitan in distribution, being exceeded in this respect probably by man alone. It includes more than a thousand genera and several times that number of species and subspecies. In his recent check-list of Kansas mammals, Hibbard records twenty-five genera of rodents with fifty-nine species and subspecies living in this state, while thirty-six genera and seventy-six species are represented by fossil remains. Though found the world around, South America at the present time has the greatest variety, while in Australia, New Zealand and Madagascar they are represented by only a few genera. They are terrestrial, burrowing, aquatic or semiaquatic, arboreal (tree-dwelling), or, in a few instances, semi-volant in habit as in the case of the so-called "flying squirrels" which are provided with a sort of parachute for taking flying leaps from tree to tree. Some are agile jumpers, such as our "kangaroo rats" (an "appropriate" name, since these creatures are *not* rats and are *not* related to kangaroos!). Yet despite this diversity of habit and the accompanying structural adaptations, the order is remarkably uniform, and the various families, genera and species are generally distinguished by such minute, though constant, characters as to make it impossible in a popular account to give any adequate means for their determination. The dental formula is usually: I-1/1 C-0/0 P-0-1/0-1 M-3/3=18 or 20, but may be reduced in a few genera to I-1/1 C-0/0 P-0/0 M-2/2=12. In a num-

ber of genera there are hair-lined cheek-pouches, or pockets, in which food is transported. The stomach may be a simple bag, or a very complex organ resembling, on a small scale, that of a cud-chewing ungulate, *e.g.*, a cow. Scent glands are frequently found in rodents. The fur may be very fine and soft, even velvety in texture, or more or less replaced or intermingled with spines, or barbed quills, as in the porcupine.

As fossils rodents are known as far back as the Lower Eocene, but even then were typical in their ordinal characters and give little direct evidence of their relationships to other mammals. Apparently they were derived from one of the early insectivore groups in the Paleocene, or even Upper Cretaceous. The known fossil rodents from Kansas belong to nine families, and range from the Middle (or possibly Lower) Pliocene to Recent, and represent all three of the suborders into which the *Rodentia* are usually divided. These suborders are termed: (1). *Sciuromorpha,* i.e., the squirrels and squirrel-like forms; (2) *Myomorpha,* i.e., the rats and mice and their like; and (3) *Hystricomorpha,* or porcupines and their near kin. The *Sciuromorpha* include all the more primitive rodents both living and fossil, the other two suborders having arisen from this stem.

Four superfamilies of sciuromorphs may be recognized, two of them known only from fossil representatives, while the other two include forms still living. Of these superfamilies, that known as the *Aplodontoidea* is the oldest in point of time and most primitive in structure. Of the six families in this group, two have fossil representatives recorded from Kansas. The first and most generalized is that of the *Ischyromyidae* which is known from the Paleocene to Pliocene of North America, with some genera in the Tertiary of Asia and Europe. The representative of this family from Kansas is the latest known, geologically speaking, *viz., Kansasimys dubius* Wood (holotype: KUMVP, No. 3582) from the Middle Pliocene, near the base of the Ogallala formation, Edson beds, Sherman County.

This species has four nearly equal lower cheek-teeth, *i.e.*, the fourth premolar and the three molars. The pattern of these teeth resembles very closely that of two Eocene genera, namely, *Ischyromys* and *Sciuravus,* which are among the most primitive forms in the order. According to Dr. Albert E. Wood, who described it, "the resemblance of this form to the Eocene *Sciuravus* is so great that, at first sight, one is tempted to place it among the *Sciuravidae.* More

careful study of the teeth, though revealing important distinctions, confirms many of the resemblances. . . . In size the two genera are fairly similar. . . . In the premolar, the similarity of *Kansasimys* to *Ischyromys* is marked, for the anterior half of the tooth is almost the same in the two genera. . . . [Yet] the greatest similarity is found in the Middle Eocene *Sciuravus,* a relatively primitive form, which may actually be related to *Kansasimys.*"

It is certainly interesting, not to say surprising, to find here in the Pliocene of Kansas, a form that has to so great an extent retained so many of the characters of the earliest known members of the *Order Rodentia.*

Probably the most primitive of living rodents is the so-called Mountain Beaver or Sewellel, confined to a relatively narrow strip along the Pacific Coast from British Columbia to California. It is little known though first discovered by Lewis and Clark in the first decade of the nineteenth century, when on their famous exploring expedition to the Northwest country. It is a burrowing, robust, squirrel-like mammal that appears to be tailless. The head is heavy and blunt, with small eyes and ears. It is about fourteen inches long. There is but one recognized species with nine subspecies. It is typical of the family *Aplondontidae* which ranges in time from the Eocene to Recent in North America, with Asiatic representatives from the Pliocene to Recent—evidently emigrants from North America. No fossil aplodontids are known from Kansas.

Closely related to and resembling the Mountain Beaver in size and form is an extinct family, known as the *Mylagaulidae,* which has a geological range from the Oligocene to the Pliocene, and is recorded only from North America. From the Middle Pliocene, Edson beds, Sherman County, has been recorded by Hibbard a rodent belonging to a species originally described by Cope under the name of *Mylagaulus monodon.* It is the representative of the strangest, most extraordinary, and bizarre family of rodents of all time. The type specimen of another species, *Mylagaulus sesquipedalis* Cope, 1878, was collected by R. S. Hill in the Lower Pliocene, Ogallala formation, on Sappa Creek, Decatur County, Kansas.

The genus *Mylagaulus* shows a notable specialization over the ischyromyids, from which its family arose, in the enormous development of the fourth premolar and the concomitant reduction of its molars. Its skull is very broad and there is a process of the frontal bone (*postorbital process*) partially enclosing the orbit of the eye behind. The lower jaw is short and stout. The molar teeth

have several enamel-islands lying parallel to the length of the jaw. The limbs are stout and the feet adapted to burrowing. The shin bones (*tibia* and *fibula*) are not united. According to Riggs, the mylagaulids were derived directly from *Meniscomys*, an aplodont genus that occurs in the John Day beds (Lower Miocene) of Oregon.

Related to *Mylagaulus* is the genus *Ceratogaulus* (or *Epigaulus*) of the Miocene and Pliocene, which alone among all known rodents of any epoch has *horns*, which are, however, mere dermal ossifications resting upon the skull but *not* attached to it. A nearly complete skeleton, the type of *Epigaulus hatcheri* Gidley, 1907 (U. S. Nat. Mus., No. 5485) was collected by John Bell Hatcher in 1885 near Long Island, Phillips County, from the Lower Pliocene (or, possibly, Upper Miocene) and was described by Gidley as a "horned rodent from the Miocene of Kansas."

Epigaulis minor Hibbard (type: KUMVP, No. 6886) came from the Lower Pliocene of Trego County. The specimen consists of the skull, associated rami of the lower jaw, and other skeletal elements of an old adult. The horns are not as high or as heavily developed as in *Epigaulus hatcheri,* though located posteriorly on the nasals with their posterior borders on a line with the anterior borders of the orbits.

A second superfamily of the suborder *Sciuromorpha* is that known as the *Sciuroidea,* a group that comprises the ground squirrels, tree squirrels, flying squirrels, chipmunks, woodchucks, prairie dogs, and beavers. Among these the family *Sciuridae* includes the more primitive forms. They are small to fairly large mammals, slender to robust in build, with a rounded head and a hairy tail that may be short or long. The teeth are typically twenty-two in number, with the formula: I-1/1 C-0/0 P-2/1 M-3/3=22; the molars are rooted, with the crown tuberculated. Some are arboreal, as the tree squirrels; some are terrestrial, and still others are burrowing in habit. As fossils, more than thirty species, belonging to ten genera, have been recorded from Kansas. The most abundant as well as most varied are the ground squirrels of the genus *Citellus,* which has thirty-two species and thirty-six subspecies living today. Of these, three species with six subspecies occur in Kansas.

Citellus is a terrestrial and burrowing squirrel which seldom or never climbs trees; its claws are long and somewhat curved, adapted to digging. Many of its species are common on deserts or treeless plains. The tail is shorter and less bushy than that of a tree squir-

rel. *Citellus* is seldom found far away from a burrow into which it darts upon the first suspicion of danger. Our most common living species is the Thirteen-lined Ground Squirrel (*Citellus tridecimlineatus*), which prefers dry open country, and is not found in forests or on marshy ground. The "tent-peg" pose when on the alert is well known.

In the Rexroad fauna, of Meade County, Hibbard has recovered five species of *Citellus,* three of them indeterminate. Two others are represented by remains sufficiently complete for specific identification. Of these two, *Citellus howelli* Hibbard KUMVP, No. 4598, the type; and No. 4585 and No. 4586 referred) is a ground squirrel slightly larger than the living Rio Grande Ground Squirrel, which is about 12½ inches long, including the 5-inch tail, but smaller than the other known Pliocene and Pleistocene species of this genus. The second species, *Citellus rexroadensis* Hibbard (type: KUMVP, No. 4608; referred: No. 4587, No. 4588 and No. 4732) is a large ground squirrel which differs from other known forms from the Plains region, either living or fossil, both in size and in the shorter and heavier lower jaw.

From the Middle Pliocene of Clark County, Hibbard has described *Citellus* (*Pliocitellus*) *fricki* (type: Frick Collection, American Museum of Natural History, No. 24627). This is a ground squirrel slightly larger than *Citellus franklini* (Sabine), the Franklin's Ground Squirrel, living in eastern Kansas, which is about fourteen inches long, including the five-inch tail. The skull of this fossil species is slender and narrow, with a rounded brain-case flattened on top like that of Franklin's squirrel. Its upper molars are broader than long. The length of the skull from the tip of the nasals to the posterior edge of the occipital condyles is 2¼ inches. The nasals extend forward well beyond the incisors. The lower jaw is heavier than that of *C. franklini.* This species resembles the Recent *Citellus* in the size and crown pattern of its molars, but in skull characters it is closer to other fossil species than it is to the living forms. In fact, it is not closely related to any previously known species of this genus.

From the Pleistocene Interglacial, Borchers fauna, of Meade County, Hibbard has described two species of *Citellus* as *C. meadensis* and *C. cragini.* The first, or Meade Ground Squirrel (type: KUMVP, No. 6169; paratype: No. 6119), is approximately 12½ inches long, but is smaller than most other known fossil species of *Citellus,* while from *C. howelli,* which also is small, it is distin-

guished by the narrower width of its molar teeth and some other more technical tooth characters. *Citellus cragini* (type: KUMVP, No. 6168) is larger than Franklin's Ground Squirrel (*i.e.*, it was apparently more than 14 inches long), and in the size and form of the last molar differs from all other known fossil and Recent forms. Hibbard named this species "for F. W. Cragin who collected the first vertebrate fossils from this area," and who was for some years on the faculty of Washburn College in Topeka.

Another species, *Citellus richardsonii*, first described by Sabine in 1822 from Saskatchewan, Canada, is recorded as a fossil from the Upper Pleistocene of Sheridan and Finney Counties, and still another, *Citellus elegans* (Kennicott), first described from Fort Bridger, Uinta County, Wyoming, was recovered from the same Upper Pleistocene deposit of Finney County. An undetermined species of *Citellus* occurs in the Pleistocene, Rezabek fauna, of Lincoln County. *C. richardsonii* (Sabine), *C. elegans* (Kennicott), and *C. tridecimlineatus* (Mitchell) have all been recorded from the Upper Pleistocene, Jones fauna, of Meade County.

The familiar Prairie Dog, living on the prairies and treeless plains, is not a "dog" in any sense of that word, but is rather a gregarious, plump-bodied, short-tailed ground squirrel. It belongs to the genus *Cynomys* which comprises six species and subspecies, all confined to western North America. It was one of the animals that attracted the notice of Lewis and Clark, and every other early explorer or traveller through the region where it abounds. The great extent of some of the Prairie Dog "towns", and the supposedly friendly relations it had with rattle-snakes and burrowing owls were often set forth embroidered with fanciful detail that has not always stood the test of more critical observations. It is now known that the snakes and owls feed upon young Prairie Dogs when the opportunity is offered, while the "dog" is not averse to making an occasional meal of a young owl, though otherwise strictly a vegetarian in its diet, and he has been reported to "bury a rattlesnake alive when he gets one down a hole" (Anthony). Due to extensive campaigns of extermination, this fat, saucy Ground Squirrel is by no means so common over much of its range as formerly, but as late as 1901, Vernon Bailey recorded a practically continuous "town" 100 miles wide by 250 miles long and containing an estimated population of 400,000,000 individuals.

An extinct species of Prairie Dog, *Cynomys vetus* (type: KUMVP, No. 6187) was described by Hibbard from the "early

phase of the Loveland loëss", Pleistocene, of Jewell County. This is a form smaller than some other species of Prairie Dog and differs also in certain characters of the teeth and palate. The same species and subspecies as that still living in Kansas, *viz., Cynomys ludovicianus ludovicianus* (Ord), has been recorded from the Upper Pleistocene, Cragin Quarry, and the Jones fauna, both of Meade County. It has likewise been found in the Upper Pleistocene at the Pyle Ranch in Clark County, as well as in Russell County (KUMVP, No. 6286), where the fossils were taken along a bluff from old burrows in the flood plain sediments of the intermediate terrace, twenty-nine feet below the surface. Another specimen (KUMVP, No. 517) came from a position eleven feet from the base of a twenty-five foot terrace along the Republican River in Cheyenne County.

A tree squirrel of the genus *Sciurus,* but species undetermined, occurs in the Middle Pliocene, Ogallala formation, Edson beds, of Sherman County, as reported by Hibbard without citation of other data. This is the genus to which the familiar Gray and Fox Squirrels belong, and it is known from the Miocene to Recent in Europe and North America, and from the Pliocene to Recent in Asia and South America.

FIG. 5.—Ground-squirrel, Eutamias. Photograph from life by W. W. Dalquest.

A chipmunk of the genus *Tamias* or *Eutamias* (Fig. 5) otherwise not more definitely determined, has been reported by Hibbard from the Rexroad fauna, of Meade County. At the present time the genus *Eutamias,* with its fifty-seven species and subspecies, is confined to the western half of North America, while the genus *Tamias* has but one species with five subspecies, and is confined to the eastern half of this continent. Both are true squirrels but spend most of the time on or near the ground, living in burrows or hollow logs, though the eastern form may climb low trees to feed upon their

buds. These little bright-colored, striped squirrels are well known to every boy who lives where they abound. From the present distribution of these two genera, it would seem more likely that the fossil from Meade County is really *Eutamias.*

A second family of sciuromorphs is that of the beavers, known as the *Castoridae.* The living beaver belongs to the genus *Castor* (Fig. 6), of which there are three species and more than a dozen

FIG. 6.—Beaver. Photograph from life by W. W. Dalquest.

subspecies in North America. Formerly occurring over most of this continent as far south as the Rio Grande, it was largely exterminated over much of its range, though now common in many places where it has been reintroduced or protected by man. There is but one record known to me of a fossil *Castor* from Kansas, and that is an undetermined species from the Upper Pleistocene, on the XI Ranch, in Meade County, reported by Hibbard. However, the genus is known elsewhere from the Pliocene to Recent in Europe, Asia, and North America. The Kansas specimen (KUMVP, No. 4727) is interesting in that it is the first evidence of this beaver in the Pleistocene of this state. Its dentition, as described by Hibbard, is peculiar but it is uncertain whether or not this is merely a case of individual variation.

A new genus of beaver was described by Hibbard from the Rexroad fauna, Meade County, as *Procastoroides lanei* (type: KUMVP, No. 3843). It has "strongly hypsodont prismatic teeth with the

base of the tooth open even in extremely old and heavily worn teeth." It is very much larger than the living beaver, though smaller than the genus *Castoroides* described below. According to Hibbard "it is a form that bridges well the gap between *Dipoides* and *Castoroides.*" *Dipoides* is a rather primitive genus of beaver from the Pliocene of Europe, Asia and North America. To have given rise to *Castoroides,* the giant beaver of the North American Pleistocene, *Procastoroides* would have only to produce some minor changes in its tooth pattern and in the position of the lower incisor. It is too far advanced and specialized to have been directly ancestral to the living *Castor.*

Two other specimens (KUMVP, No. 3939 and No. 3940) from the same horizon represent a beaver too small to be included in *Procastoroides lanei,* unless this species has an unusual amount of variation in size, which seems hardly likely. They do not represent age differences, since the teeth are well-worn, indicating adult individuals. They may possibly belong to *Procastoroides sweeti* Barbour and Schultz, reported by those authors from Nebraska.

The genus *Castoroides* is remarkable for its huge size, for it had the dimensions of a black bear. A very fine skull (KUMVP, No. 3196) was found about 1900, at a depth of 34 feet below the surface while sinking a coal-mine shaft 3½ miles southwest of Boicourt, Linn County. This specimen was described and named *Castoroides kansensis* by the late H. T. Martin and was at the time the second specimen of its genus found west of the Mississippi River, the first coming from Dallas, Texas. About two dozen specimens have been recorded from as many localities east of that river. Martin's species is now more generally considered as belonging to the previously described *C. ohioensis,* to which the eastern specimens have been uniformly assigned.

However, Martin distinguished his species, *C. kansensis,* from *C. ohioensis* on the basis of the proportionally larger incisors, with narrower grooves and their greater number; the relatively longer diastema between the incisors and the molars; the difference in the pattern of the enamel folds in the last molar, and its comparative smallness; the difference in the frontonasal region of the skull; the comparatively larger nasals; and the deep, rugose pittings of the parietals.

An undetermined species of this genus is recorded by Hibbard from the Upper Pleistocene, Rezabek fauna, of Lincoln County.

What the habits of this giant beaver may have been, no one,

of course, can say with authority, but there would seem to be no reason to suppose that they were markedly different from those of the living beaver. *Castoroides* probably built huge dams across the Pleistocene streams of Kansas and constructed huge houses in which to live. The pelt of one such beaver would have been large enough to make an entire coat for a large man.

Hibbard has recorded another beaver, *Eucastor tortus* Leidy (No. 24622, Frick Coll., Amer. Mus. Nat. Hist., N. Y.), collected by George Sternberg in 1933 on the Selbe Ranch, eight miles northeast of Phillipsburg, Phillips County, from the Lower Pliocene. The chief importance of this fragmentary specimen lies in the fact that "its occurrence helps to establish proof of the existence of deposits of that age in Kansas" (Hibbard). It is distinguished altogether by such technical characters of the teeth as to make it impossible to give a satisfactory description of the species here. This species was described many years ago by Joseph Leidy, of Philadelphia, the outstanding vertebrate paleontologist of America about the middle of the nineteenth century. Hibbard and Phillips also report *Eucastor* cf. *tortus* (KUMVP, No. 6885) from Trego County, Kansas.

We may recognize as the third superfamily of sciuromorphs that known as the *Geomyoidea,* of which there are two families represented by fossil species from Kansas. The first family, called the *Geomyidae,* includes the familiar pocket-gophers, burrowing rodents with large strong claws on the front feet for digging; hair-lined cheek-pouches opening to the outside;* head broad and neck short; eyes and ears small; body robust; tail short, thick at base, and scantily haired; legs short and stout. Darker colored above, somewhat lighter below in both sexes. The males reach a length of 10½ inches; the females, 9 to 10 inches. These rodents do much damage in alfalfa or clover fields where they burrow and throw up large piles of loose earth at intervals.

The pocket-gophers of the western United States are mostly of the genus *Thomomys,* while the eastern forms belong to the genus *Geomys.* The ranges of the two may overlap along the eastern foothills of the Rocky Mountains.

In Kansas, the fossil geomyids have, so far, been taken mostly in Meade County. They occur in the Rexroad fauna, where Hibbard has recorded an undetermined species of *Geomys* (KUMVP, No. 3926), with a peculiar crown pattern on the molar teeth. It appears

*The hair-lined cheek-pouches which open *outside* the mouth are absolutely unique among mammals.

to have been smaller than the living *Thomomys fulvus intermedius* Mearns, which reaches a length of only 8 inches in both sexes, and occurs today in southwestern New Mexico and southeastern Arizona. Another undetermined species of *Geomys* (KUMVP, No. 4576), from the same horizon in Meade County, is about the size of the living *Geomys lutescens*—10½ inches long in the males, with the females about one inch less—which occurs today in western Kansas and neighboring states. Several other fragmentary specimens, some indicating a species as large as *Geomys bursarius,* i.e., up to 12 inches long, of the Mississippi Valley, were recovered from the same formation in Meade County, but cannot be assigned with certainty to any known species. From the Big Springs faunule of the Rexroad, Hibbard records a specimen of *Geomys lutescens* (Merriam) (KUMVP, No. 3959). Undetermined species of the same genus are also known from the Pleistocene Interglacial, Borchers fauna, of Meade County; and from the Pleistocene, Rezabek faunt, of Lincoln County.

Recently Dr. Dorothea S. Franzen has distinguished a Pocket Gopher, *Geomys quinni* McGrew, from the Rexroad fauna, on the basis of several fragmentary mandibles and numerous isolated teeth, collected by field parties under Dr. C. W. Hibbard in Meade County. Several dental characters render this species quite distinct from other hitherto described forms of this genus. The specimens are in the University of Kansas museum.

From the Upper Pleistocene, Meade formation, Tobin faunule, of Russell County, Hibbard has described a fossil gopher under the name of *Parageomys tobinensis* (type: KUMVP, No. 6652), and a paratype of the same from the same horizon in Meade County). This is a small gopher in some respects more like *Thomomys* than *Geomys,* from both of which genera it is distinguished by peculiar tooth characters. Like in other geomyids, the jaw and teeth probably increased in size with age, and the small size of the type specimen of *Parageomys tobinensis* may be due in part to immaturity.

A second family of the Geomyoidea is that known as the *Heteromyidae,* the Pocket Rats and Pocket Mice, which is represented by several genera with fossil species from Kansas. The living heteroomyids are small rodents with fur-lined cheek-pouches, but with the fore feet not developed for digging, *i.e.,* lacking the large claws of the geomyids, yet some, at least, have the burrowing habit, evidently a comparatively recent acquirement. The head and body are rather slender, and the tail is usually very long, equaling the head and body

together in length. The fossil species of the family known from Kansas include two, belonging to as many genera, from the Middle Pliocene, Ogallala formation, Edson beds, of Sherman County. The first of these is Dunkle's Pocket Mouse (*Perognathus dunklei* Hibbard; type: No. 6203, Mus. Comp. Zool., Harvard), which is the smallest of the known fossil forms of this genus, apparently about the size of the living *Perognathus flavus flavus* Baird, which is only 4½ inches long and occurs from northeastern Colorado and western Nebraska to northern Mexico. The second species from the Edson beds is *Prodipodomys kansensis* Hibbard. This genus is distinguished by the *rooted* condition of the last premolar and first molar in the lower jaw. It differs, moreover, by a number of even more technical characters, including the presence of a well-developed foramen (opening) between the last lower molar and the base of the ascending process (*coronoid*) of the mandible.

From the Rexroad fauna, of Meade County, Hibbard records two species of *Perognathus,* one indeterminable, the other named *Perognathus gidleyi* Hibbard (type: KUMVP, No. 776; paratype: No. 5928). This is a Pocket Mouse, probably about 7½ inches long, distinguished from other fossil species by its smaller size and the crown pattern of its molar teeth, which is more nearly like that of the living species than that of the other fossil forms. The cusps of its molars are also more distinct. As Hibbard notes, it "approaches the recent forms of *Perognathus* more closely than any previously described fossil species, though it is distinguished from them by deeper reëntrant angles and valleys in its teeth than are to be found in the recent forms of comparable dentitional wear."

Also from the Rexroad fauna of Meade County is another heteromyid described by Hibbard under the name of *Liomys centralis* (type: KUMVP, No. 589). This genus is represented by a species, *Liomys irroratus texensis* (Merriam), the Texas Spiny Mouse, living on the low plains of southern Texas southward into Mexico, where other species also occur. Altogether this genus comprises 10 species and 22 additional subspecies in its range. *Liomys centralis* is slightly larger than the Recent species in Texas and its teeth vary from it in details of crown pattern. It was an animal probably nearly ten inches long, and apparently closely resembled its modern relatives.

From the Pleistocene Interglacial, Borchers fauna, of Meade County another fossil species, *Perognathus pearlettensis* (type: KUMVP, No. 6127) has been described by Hibbard. This may be

called the Pearlette Pocket Mouse, and seems to have been nearly as large as *Perognathus apache* Merriam, about 5½ inches long, which occurs today in the area including western New Mexico, eastern Arizona and southern Utah. Hibbard remarks that "*Perognathus pearlettensis* is distinguished from the following Recent High Plains species, *P. fasciatus* Wied, *P. flavescens* (Merriam), and *P. flavus* Baird, by its slightly larger size, heavier incisors, more robust and shorter diastemal region of the ramus, greater depth of ramus below the posterior border of the second molar, and a more robust condylar process. *Perognathus flavescens* and *P. flavus* now inhabit the region in which the fossil species was collected." It was

FIG. 7.—Peromyscus. Photograph from life by W. W. Dalquest.

named for the "Pearlette ash" bed, from which the specimens, altogether ten in number, were taken. The genus *Perognathus* is now represented by a total of 104 living species and subspecies.

The second suborder of rodents is known as the *Myomorpha,* the typical mice and rats of the world. At least three families of this suborder are known from fossil species in Kansas. The first of these is the family *Cricetidae,* which includes our *native* rats and mice, but not the familiar, but introduced, house-mouse and common Norway rat. The *Cricetidae* have never more than three molariform teeth on each side above or below; the canines and premolars are all absent. The crown pattern of the molars is made up of two primary longitudinal rows of tubercles, or of angular figures. The subfamily

Cricetinae has rooted molars with tubercles situated in two parallel anteroposterior rows. About a dozen genera of cricetines have been recorded among the fossils from Kansas as follows.

The cricetine genus *Peromyscus* (Fig. 7), the familiar and very common Deer Mouse, or White-footed Mouse, with 163 known living species and subspecies—5 of these recognized as full species—is found over practically all of North America south of the 60th parallel of latitude, except in northwest Canada (Yukon) and Alaska where it reaches the 65th parallel. The sexes are alike in size and coloration with darker upper parts and clear white below. They vary in different species from 3¾ to 10½ inches in length. As Anthony points out, "the differences between the various forms are often too subtle to depict in a short written description." And Dr. Hibbard notes that the genus *Peromyscus* seems to have been the paleontologist's "catch-all for many forms since the Oligocene." Whether the genus even existed as early as the Upper Pliocene in North America is questionable.

Two species of fossil *Peromyscus* are recorded from the Rexroad fauna, of Meade County. These are *Peromyscus eliasi* Hibbard (type: KUMVP, No. 3941) and *Peromyscus kansasensis* Hibbard (type: KUMVP, No. 4597). The first of these, *P. eliasi,* is a mouse probably about 6 inches long, somewhat heavier in build than the living *P. maniculatus osgoodi* Mearns, which occurs today along the eastern base of the Rocky Mountains from south central Saskatchewan to the Panhandle of Texas. The type specimen is an old adult with greatly worn teeth, but with the valleys between the cusps deeper than those of recent forms. A number of other fragmentary specimens were recovered from the same site, all with the same crown pattern in the teeth and of the same size.

Peromyscus kansasensis Hibbard is apparently a very large species comparable in size to the living *P. californicus,* which reaches a length of 10 inches or a little more. However, it is not as large as several other known fossil species. It is otherwise distinguished only by technical characters of the teeth and jaw not necessary to give here.

Peromyscus, without specific identification, has also been recorded by Hibbard from the Pleistocene, Cudahy faunule, and the Jones fauna, both of Meade County.

From the Middle Pliocene, Ogallala formation, Edson beds, Sherman County, Dr. David Dunkle collected a fossil Rice Rat, which Hibbard has described under the name of *Oryzomys plio-*

caenicus (type: No. 6202, Mus. Comp. Zool., Harvard). The genus *Oryzomys* has 60 living species and subspecies, but most of them occur only in tropical America, only two species with five subspecies occurring in our south Atlantic and Gulf states, one extending into eastern Kansas. None is now found in central or western Kansas. They are inhabitants of grasslands, marshes, or open brush land. The fossil specimen represents a small cricetine rodent and is an old adult with greatly worn teeth. Due to the incompleteness of the specimen the reference to *Oryzomys* may be questionable, but it resembles this genus more nearly than any other hitherto described.

A second cricetine from the Middle Pliocene, Edson beds, of Sherman County, is Martin's Grasshopper Mouse, *Onychomys martinii* (Hibbard) (type: KUMVP, No. 3850). This seems to be the earliest known occurrence of this genus, which has twenty-six known species and subspecies living in western North America from Manitoba to British Columbia southward through the western United States into Mexico. Known as Grasshopper Mice, the individuals typical of this genus are rather plump, five and a half to six and a half inches long, with a relatively short, thick tail. Both sexes are alike in coloration, usually dark above and white below. *O. martinii* is apparently one of the larger forms.

Onychomys gidleyi Hibbard (type: KUMVP, No. 4669) is a Grasshopper Mouse recovered from the Rexroad fauna, of Meade County. It was probably about 6 inches long. Its specific characters are technical and mostly concern the teeth. Another species, *Onychomys fossilis* Hibbard (type: KUMVP, No. 5238) is from the Pleistocene Interglacial, Borchers fauna, of Meade County. Slightly smaller than *O. gidleyi,* it too is not otherwise distinguishable except by anatomical characters of a technical nature.

The living *Onychomys* is of particular interest because of its habit of preying upon other sorts of mice as well as upon grasshoppers. It is thus of considerable economic importance to the farmer because of its astonishing appetite. In captivity one *Onychomys* was observed to eat during one night another mouse "of about its own size. . . . The next night it ate another about half its size, and the third night a third mouse, about as big as the first one. . . . On the fourth morning, in spite of three heavy cannibalistic banquets in succession, it breakfasted on three large grasshoppers and some rolled oats. . . . A mouse a night, or twenty grasshoppers, represents a really considerable contribution in the way of pest removal" (Bailey and Sperry).

From the Rexroad fauna, of Meade County, Hibbard has described five other species of fossil cricetine rodents belonging to as many genera. The first of these is *Baiomys rexroadi* (type: KUMVP, No. 4670), representing a genus of tiny mice, rare and little known as to habits, closely related to *Peromyscus,* with only one species and two subspecies living in southern Texas. *B. rexroadi* was a mouse approximately 3½ to 4½ inches long, and is distinguished from other species, either living or fossil, mainly by tooth characters. The second is called *Sigmodon intermedius* Hibbard (type: KUMVP, No. 3887). The living species of *Sigmodon* are known as Cotton Rats and range generally from 10 to 12 inches in length. The genus today comprises thirty-seven species and subspecies, of which fourteen subspecies belonging to only three species are found living in the southern states and northward into northern Kansas. *Sigmodon intermedius,* as its name implies, is intermediate in size between other known fossil relatives, from which it differs also in certain tooth characters. In addition to the type nine other specimens were secured by Hibbard from the Rexroad fauna of Meade County. "The amount of *Sigmodon* material recovered indicates that the genus was well established and filled an important niche during the time the Rexroad fauna inhabited that area. It is interesting to note that *Sigmodon* was also common in the Benson fauna from the Upper Pliocene of Arizona. By the Upper Pliocene, *Sigmodon* had become well differentiated and abundant in faunas, thus representing the earliest known form of the genus. At present our earlier Pliocene faunas have thrown no light on its origin; although from the study of material in faunas where it appears, it has proven to be a rather conservative form and has undergone but minor changes since the Upper Pliocene. There are a number of South and Central American genera . . . that are closely related to its ancestral stock" (Hibbard).

Sigmodon hilli Hibbard (type: KUMVP, No. 5431) was described from the Borchers fauna, Pleistocene Interglacial, of Meade County. This species, represented by about 150 specimens in the K. U. collection, is slightly smaller than *Sigmodon intermedius* Hibbard, and is further distinguished from this and other species by tooth characters.

Parahodomys quadriplicatus Hibbard (type: KUMVP, No. 4496) represents an extinct genus from the Rexroad fauna known previously from *P. spelaeus* Gidley and Gazin from the Pleistocene of the Cumberland Cave in Maryland. *P. quadriplicatus* is of nearly

the same size as *P. spelaeus,* but differs in a number of tooth characters. It shows some resemblances to the Pack Rat (*Neotoma floridana*) though it certainly could not have been ancestral to it. It is also related to certain genera found in South America today.

Symmetrodontomys simplicidens Hibbard (type: KUMVP, No. 4601), represented by nine specimens from the Rexroad fauna, Meade County, is a mouse-sized rodent distinguished from all other known fossil and living forms by its *opposite* cusps on the second lower molar in adult stage of wear; by the broad open valleys between the cusps; and by the unreduced third lower molar. This genus, as Hibbard notes, "possesses more characters in common with the Central and South American cricetine rodents than with those of North America."

With some question Hibbard assigned five fragmentary specimens from the Rexroad fauna of Meade County to the species *Eligmodontia arizonae* Gidley, but it seems more likely that the assignment should be to the genus *Bensonomys.* He notes that "this form is distinct from other fossil and living genera and its relationship seems to be closer to Central and South American forms than to mice now found in North America." This genus may have originated in North America in Lower or Middle Pliocene, migrating later to Central and South America, where it seemingly gave rise to the forms now living there, while it became extinct on the continent of its origin.

The genus *Reithrodontomys,* the Harvest Mouse, is represented by sixty-nine living species and subspecies, of which there are seven species and fifteen subspecies ranging from the Atlantic to the Pacific in our southern states, and northward in the Great Plains; one, *R. megalotis dychei,* occurs over most of Kansas, the type specimen of which was collected at Lawrence, Kansas, and was named for Professor L. L. Dyche. The genus is represented in the Pleistocene Interglacial, Borchers fauna, of Meade County, by the species *Reithrodontomys pratincola* Hibbard (type: KUMVP, No. 6167), as well as by an undetermined species reported by Hibbard from the Pleistocene, Rezabek fauna, of Lincoln County.

A typical Harvest Mouse closely resembles the ordinary House Mouse, being 4½ to 5 inches long, dark brown above and grayish below, with large ears, a long slender tail, no cheek pouches, but with the upper incisors longitudinally grooved. *R. pratincola* Hibbard is a Harvest Mouse smaller than the living *R. albescens griseus* (Bailey), which ranges from southeastern Nebraska, southwestward

over about two-thirds of Kansas, much of Oklahoma, Texas, and eastern New Mexico. The latter species varies from 4¾ to 5 4/5 inches in length. The fossil species is distinguished by tooth and jaw characters. It is much smaller than *Reithrodontomys simplicidens,* a fossil form described by Barnum Brown from the Conard fissure, Pleistocene, of Arkansas.

The Wood Rats, or Pack Rats, of the genus *Neotoma* reach a length of approximately 16 inches and are widely distributed over much of the United States from New York to California, and from Yukon, British Columbia and Alberta on the north to Texas, New Mexico, Arizona and southern California on the south, with by far the greatest number of species in the western half of this country, where nearly every peculiar type of environment has its own distinct race. An undetermined fossil species of *Neotoma* is recorded by Hibbard from the Pleistocene, Rezabek fauna, of Lincoln County.

A new genus of cricetine rodent has been described by Hibbard under the name *Cudahyomys moorei* (type: KUMVP, No. 6690) from the Pleistocene, Meade formation, Cudahy faunule, of Meade County. This is a mouse, probably 6 to 7 inches long in life, which is distinguished by its own peculiarities of teeth and jaw. It is apparently not closely related to any other cricetine from the Pliocene or Pleistocene. The tooth pattern is quite distinct, but the mandible is much like that of *Reithrodontomys.* The species was named for Dr. Raymond C. Moore.

The genus and species, *Etadonomys tiheni* Hibbard (type: KUMVP, No. 6461) is a heteromyid rodent, approximately 10½ inches long in life, from the Pleistocene Interglacial, Borchers fauna, Meade County. It differs from other fossil and recent forms in a number of characters of the teeth and jaw and appears to be quite distinct. It was named in honor of Dr. Joe A. Tihen, who has spent a number of years collecting vertebrate fossils in Kansas.

The second subfamily of the *Cricetidae* is that termed the *Microtinae,* and includes the forms known familiarly as the voles and lemmings. They have flat-crowned molars with a surface pattern of angular figures, *i.e.,* >'s and triangles. They are terrestrial, burrowing, or, in some cases, semi-aquatic in habit. The dental formula is: I-1/1 C-0/0 P-0/0 M-3/3=16. They look very much like small short-tailed meadow mice, but differ in skull and tooth characters. They are rather heavy-set with a very short tail. The incisors are orange-colored, and the upper ones are grooved longitudinally. The thumb is provided with a flat, strap-shaped *nail,*

while claws are present on the other fingers and toes. They prefer bogs and swamps as dwelling places. Ten genera with 161 species and subspecies occur in North America north of Mexico.

Our knowledg of the fossil microtines of Kansas, as is the case with several other groups of fossil rodents, is due mostly to the work of Dr. C. W. Hibbard, now of the University of Michigan. From the Rexroad fauna, of Meade County, he has described a new genus and species, *Pliolemmus antiquus* (type: KUMVP, No. 3889), a small lemming with rootless teeth, growing throughout life, with no cement filling their external reëntrant angles. The bases of the incisors extend well back into the body of the jaw along the *lingual* (tongue) side of the roots of the molars. Hibbard looks upon this species as "the most generalized form of the lemmings in its simple tooth structure, greatly elongated base of the incisor and dorsally located mental foramen." The "mental foramen" is an opening in the jaw bone situated so high upon the latter toward its anterior (or "chin") end "that a line drawn from the middle of the anterior [enamel] loop of the first lower molar to the middle of the incisor at the base of its alveolus [socket] would pass along its lingual border."

A second microtine genus recorded by Hibbard is *Synaptomys,* or Lemming Mouse, represented by 15 living species and subspecies, of which two species with two subspecies occur in the United States. It is seemingly rather rare, often of local and sporadic occurrence, and little is known about its habits. It is from four to five inches long. From the Pleistocene Interglacial, Borchers fauna, of Meade County, Hibbard lists *Synaptomys* cf. *vetus* Wilson, the "Old Lemming Mouse", differing a little from the type of Wilson's species from the Grand View fauna (see: Carneg. Inst. Wash., Publ. No. 440, pp. 124-126) in that the triangles in its molar pattern are slightly larger and more tightly closed.

Synaptomys borealis (Richardson) is represented by several fragmentary specimens (KUMVP, No. 6188, 6189, 6610, 6625 and 6658) and comes from a lower horizon in the Meade formation than the Borchers fauna, i.e., from the Cudahy faunule. It, too, is distinguished on the basis of technical tooth characters, as reported by Hibbard. From the Pleistocene on the XI Ranch, twenty-one miles south of the town of Meade, in Meade County, Hibbard describes a new lemming as *Synaptomys bunkeri* (type: KUMVP, No. 4610). The specimen is too fragmentary to warrant description here, since all its distinguishing characters concern the teeth and jaw.

Another microtine rodent has been recorded from the Rexroad

fauna, of Meade County, under the name of *Ogmodontomys poaphagus* Hibbard (type: KUMVP, No. 4594). In it the upper incisors are strongly curved and have a shallow groove along the outer edge. This species differs also from the other known fossil *Microtinae* which possess rooted teeth in the uniform thickness of the enamel ridges and in the fact that the apices of the inner reëntrant folds of the lower molars lie at right angles to the longitudinal axis of the tooth. Other characters could be noted, but they are too technical for mention here.

From the same horizon but a different site comes *Pliopotamys meadensis* Hibbard (type: KUMVP, No. 3846). This is a medium-sized vole slightly smaller than the Water Rat (*Neofiber:* see below), and the type specimen represents an adult individual. The molars are strongly rooted and the crown pattern shows open triangles. This species is intermediate in size between two other known forms of this genus, *viz., Pliopotamys idahoensis idahoensis* and *Pliopotamys idahoensis minor,* being smaller than the first and larger than the second.

FIG. 8.—Muskrat. Photograph from life by W. W. Dalquest.

The genus *Ondatra* (Fig. 8), which has three species and fourteen subspecies living in North America, is familiarly known as the Muskrat. The muskrats, which vary from seventeen to twenty-four and a half inches in length, are large, robust, rat-like rodents, with short legs and broad feet, the hind ones partially webbed for swimming. The long scaly tail is laterally compressed and has few hairs. The fur of the body is greatly prized in commerce. The common living species, *Ondatra zibethica,* has been recorded from the Rezabek fauna, Pleistocene, of Lincoln County, but in a form slightly smaller than the subspecies now living in that county. The four known fossil specimens (KUMVP, No. 6676, 6290a, 6290b, and

6677) show that the bases of the teeth are closed and possess well-developed roots. It is possible that these individuals belong to the species *Ondatra nebrascensis* Hollister, which was recovered from the Pleistocene quarries near Hay Springs, Sheridan County, Nebraska, but since both the latter and the specimens from Kansas are fragmentary, and the cranial characters on which *O. nebrascensis* was distinguished are wanting in our specimens, a direct comparison cannot yet be made.

Another species of fossil muskrat has been described by Hibbard, this one from the Cudahy faunule, Meade formation, Pleistocene, of Meade County. It is known as *Ondatra kansasensis* Hibbard (type: KUMVP, No. 6656), and is a form slightly smaller than *O. annectans* (Brown) recovered from the Conard fissure in Arkansas. The molar tooth pattern is typical of *Ondatra,* with the reëntrant angles of the anterior loop no deeper than in living species; the alternating triangles are closed in the adult; and the tooth has two well-developed roots. Besides the type, seven other fragmentary specimens at the same horizon but in various localities have been found. Still another, considerably larger muskrat (*Ondatra* sp.), from the Pleistocene Interglacial, Borchers fauna, of Meade County, is mentioned by Hibbard without further description except that its right second lower molar is 3.65 mm. long, whereas the corresponding tooth in *O. kansasensis* is only 2.65 mm. in anteroposterior dimension. A related genus of muskrat occurs in the rexroad fauna, of Meade County. This is known as *Neondatra kansasensis* Hibbard (type: KUMVP, No. 3847). It is a medium-sized vole, about equal to *Pliopotamys meadensis* in this respect, with short-crowned teeth and a distinctive dental pattern. The type is an old adult with the tooth crown well worn from long use. There is a prominent ridge on the lingual side of the alveolar border of the jaw in its posterior region, more pronounced than in any other comparable genus. The dental pattern in *Neondatra kansasensis* is nearly like that of *Pliopotamys meadensis,* except that the anterior loop of the lower first molar is exceedingly simple in the latter and highly complicated in the former genus. The lower jaw is lighter in *Pliopotamys* and more stoutly developed in *Neondatra.* Many other more technical differences serve to separate these two forms even upon casual inspection.

Hibbard interestingly remarks that in one locality of the Rexroad fauna, he has collected more than 75 isolated microtine teeth. These "teeth range from 3-rooted brachyodont [short crowned] types to old worn hypsodont [*i.e.,* high-crowned, rootless] types,

varying in size from the smallest voles to the smallest living forms of *Ondatra*. Two lower second molars are in the collection representing without question a distinct *Ondatra* pattern. These are not described at this time because it is hoped that more abundant material from the locality will throw a greater light upon [the relationship of] living and fossil forms. But it is evident that these forms had segregated themselves into distinct genera and were well on the road to many of the living genera. It is also evident that there were many primitive forms living at that time which will not fall into the modern grouping."

In the Rezabek fauna, Pleistocene, of Lincoln County, Hibbard has found a species of Water Rat (or Round-tailed Muskrat) which he calls *Neofiber leonardi* (type: KUMVP, No. 6653; and a paratype, No. 6654). This is a form larger than the living Everglade Water Rat (*Neofiber alleni nigrescens* Howell), which is a little over a foot long. Anthony remarks of *Neofiber* that it "seems to occupy a position intermediate between the Meadow Mice [*Microtus*] and the Muskrats [*Ondatra*], not only in size but, to a certain extent, in habits as well. It is not as aquatic as the muskrat, although it is found about the edges of streams and swamps and builds platforms of grass stalks in shallow water upon which it sits to feed."

Neofiber leonardi is distinguished from other species of the genus by peculiarities in its dental pattern. Hibbard named it in honor of "Doctor A. Byron Leonard who has devoted much of his time to collecting and studying Kansas faunas."

Another genus of microtines is *Phenacomys,* sometimes called the Lemming Mouse, which has only 16 species and subspecies living today in the colder parts of Canada and the mountains of the western United States. It is not known outside of the North American continent, and even here ranks as rare. The individuals belonging to this genus are small mice externally very similar to Meadow Mice (*Microtus*), from which they may be distinguished by their short-crowned rooted molars. The legs and generally the tail also are short; the color darker in summer, grayer in winter; the total length slightly under six inches. Of this genus Hibbard records *Phenacomys* (*Pliophenacomys*) *primaevus* (type: KUMVP, No. 3905) from the Rexroad fauna, of Meade County. This is a vole apparently about 5½ inches long, characterized by a more primitive dentition than that found in the living species, being low crowned and without cement in the reëntrant folds of the molar

teeth. The long base of the incisor, extending backward within the jaw bone, crosses from the lingual (tongue) side to the labial (cheek) side under the last (third) lower molar, thus far back in the jaw. The mental foramen (an opening situated on the anterior part of the mandible) is situated more dorsally on the jaw than in the living species, which, as Hibbard notes, "seems to be a tendency that existed in other primitive forms of the *Microtinae*," as well.

The Pine Mice of the genus *Pitymys* constitute a small group of small microtine rodents, rarely more than five inches long, which occur "in forested or brushy areas, but not in densely timbered regions, seeming to prefer an environment where open patches alternate with stands of brush, shrubs or trees. Their runways are not on the surface like those of Meadow Mice [*Microtus*], but are mole-like tunnels just below the surface of the ground. These tunnels are smaller than mole runways but like them in distribution and relation to the surface. There are numerous openings to the surface of the ground through which the Mice can pass in search of food, but much of the food is obtained under the surface as roots and bulbs. Pine Mice often use mole runways when these tunnels make contact with their own system" (Anthony). There are four recognized species of *Pitymys,* one of which has three subspecies, and the range of the genus is from southern New York and Connecticut, southward along the Atlantic coast to Florida, westward to Illinois and Council Bluffs, Iowa, and southward into the interior of Tennessee and central Arkansas. In a brief written description it is hard to give characters that will distinguish *Pitymys* from *Microtus,* of which some authors consider it to be only a subgenus. *Pitymys* also is known from the Pleistocene to Recent in Asia and Europe.

Hibbard has described a species of *Pitymys* from the Cudahy faunule, Meade formation, Pleistocene, of Meade County, under the designation *Pitymys meadensis* (type: KUMVP, No. 6463, with eight paratypes from the same locality). It is a vole about eight inches long, which in the adult stage is distinguished by its tooth pattern, especially by its tightly closed posterior loop and alternating triangles. The enamel is thickened on the anterior face of the triangles, which alternate in position on the lingual and labial sides of the teeth. The posterior loop is entirely cut off from the four closed triangles in front of it, and the reëntrant angles are filled with cement. The patterns of the first and second lower molars in *Pitymys meadensis* closely resemble those of the living genus *Neodon* of southeastern central Asia. *Pitymys meadensis* is

also reported by Hibbard from the silt below the ash on the Pyle Ranch in Clark County and from the corresponding horizon in Meade County.

The Meadow Mice of the genus *Microtus* are medium in size and robust in body, with a comparatively short tail. The rootless molars have crowns consisting of a series of enamel-bounded angles; the upper incisors are simple and not grooved. In total length of body and tail the species vary around six or seven inches. There are 98 species and subspecies now living in North America from the southern boundary of the United States northward to Alaska, northern Canada and Labrador. Hibbard has recorded seven fossil species of *Microtus* from Kansas, three of which are not specifically

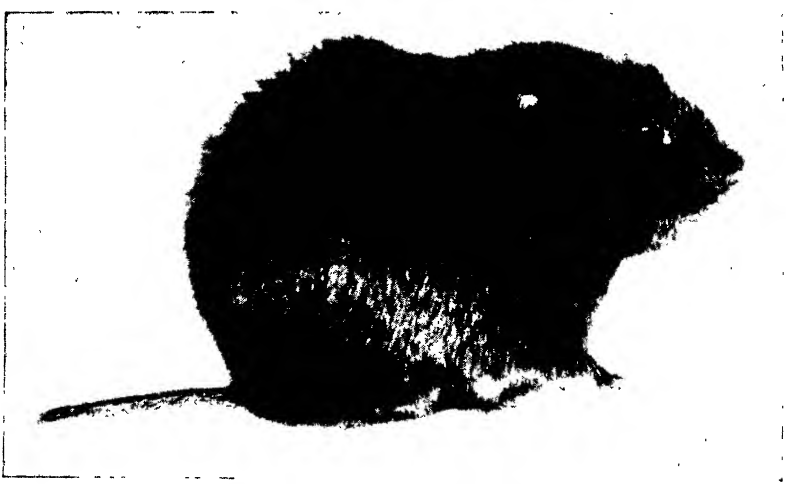


FIG. 9.—Microtus. Photograph from life by W. W. Dalquest.

identified—two from the Rexroad fauna, and one from the Pleistocene, Cudahy faunule, of Meade County. One of the species that he has identified is *Microtus pennsylvanicus* (Ord), which lives today over practically all habitable North America (Fig. 9). It is recorded as a fossil species from the Jones fauna, Upper Pleistocene, of Meade County, and the Rezabek fauna, Upper Pleistocene, of Lincoln County.

Another species is designated by Hibbard as *Microtus llanensis* (type: KUMVP, No. 6626) from the Cudahy faunule, Meade formation, Pleistocene, of Meade County. This is a small vole approximately six inches long, which Hibbard assigns to the subgenus *Pedomys,* "because of two characters, the size and relationship of

the basal capsular process for the third lower molar in relation to the angular process [of the jaw], and the well-developed foramen between the anterior outer triangle of the second lower molar and the edge of the ascending ramus [of the jaw]." However, this subgeneric assignment is not absolutely certain.

A second and abundant species of *Microtus* from the Cudahy faunule, Meade formation, Pleistocene, of Meade County, is described by Hibbard as *Microtus paroperarius* (type: KUMVP, No. 6587; with eighteen paratypes). This is a small vole approximately 7½ inches in total length of body and tail. It is thought by Hibbard to be closely related to *Microtus speothen* Cope, from the Port Kennedy bone deposit of Pennsylvania, which is probably early Pleistocene in age. The distinguishing characters of *Microtus paroperarius* Hibbard have to do with technical dental features. This species is also reported from the Tobin faunule, Meade formation, Upper Pleistocene, of Russell County, in a "gray to greenish silt and fine sand beneath the Pearlette ash member," and from the Wilson Valley faunule, Lincoln County, at the same horizon, hence probably contemporaneous with the Tobin and Cudahy faunules.

From the Rezabek fauna, Pleistocene, of Lincoln County, Hibbard has identified another species as *Microtus* cf. *ochrogaster* (Wagner). Wagner's species is a vole, six inches long, now living in the "central part of the Mississippi Valley from southern Wisconsin to southern Missouri and Fort Reno, Oklahoma, and west into eastern Nebraska and Kansas" (Bailey). The identification is made on the basis of the crown pattern of the molar teeth. The same species is also reported from the Pleistocene Interglacial, Borchers fauna, and the Pleistocene, of the XI Ranch fauna, both of Meade County.

The last family of rodents known from fossil representatives in Kansas is that of the *Zapodidae,* or Jumping Mice. They are medium-sized mouse-like rodents with greatly elongated hind legs and tail, *internal* cheek-pouches, narrow incisors grooved in front, and with the crown-pattern of the molars consisting of complex folds. They are eight to ten inches long to the end of the last tail vertebra, and are often known as "Kangaroo Mice" because when alarmed they progress by long leaps. They occur today over most of the United States and Canada from the Arctic Circle southward into North Carolina on the east and California on the west. The dental formula is: I-1/1 C-0/0 P-1/0 M-3/3=18. They are terrestrial in habit, living in meadows.

From the Pleistocene Interglacial, Borchers fauna, of Meade County, Hibbard has recorded a new fossil species as *Zapus burti* (type: KUMVP, No. 6152; paratype, No. 5341), represented by an adult specimen. The type indicates a rodent probably about nine inches long, with molars short-crowned and broader than those in comparable recent species. The enamel-fold is not so crowded and the third lower molar is reduced in size. The first lower molar has an anterior cusp separated from the rest of the tooth by a deep groove, which includes a well-developed lake of dentine "much larger than any observed in recent species in any stage of wear" (Hibbard). It is further distinguished by a number of other more technical characters in the crown patterns. Hibbard named the species for Dr. W. H. Burt, of the University of Michigan, a native of Kansas, who is an outstanding student of American mammals.

(*To be continued*)

Geographic Range of the Hairy-Legged Vampire in Eastern Mexico

WALTER W. DALQUEST and E. RAYMOND HALL
University of Kansas, Lawrence

The hairy-legged vampire bat, *Diphylla ecaudata centralis* Thomas, ranges much farther north in Mexico than is generally known, as shown by specimens recently taken in field work* seven kilometers northwest of Paraje Nuevo, Veracruz, and at Jacala, Hidalgo.

On February 12, 1946, Mrs. Leora Forbes accompanied one of us (Dalquest) to a cave, locally known as Ojo de Agua, situated approximately 7 kilometers northwest of the village of Paraje Nuevo, and the same distance east-northeast of Cordoba, Veracruz. On previous explorations of this cave, in search of archeological objects, Mrs. Forbes had discovered the nearly concealed entrance to a dry, upper-level of the cave where bats were numerous.

We first investigated the tortuous, treacherous, main cave. The

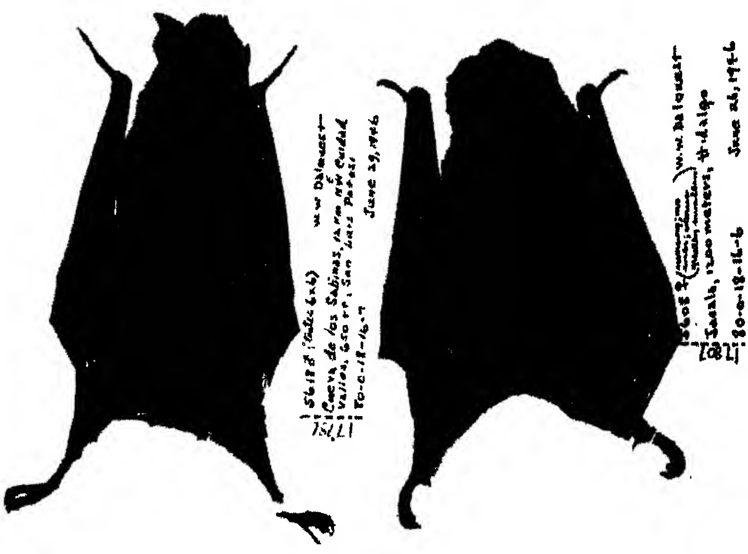


FIG. 1.—Common Vampire, Desmodus, left, and Hairy-legged Vampire, Diphylla, right. Note long thumbs with median basal pad of Desmodus, and longer ears, coarser fur and naked uropatagium, as compared with Diphylla.

Transactions Kansas Academy of Science, Vol. 50, Nos. 3 and 4, 1947.

*Assistance from the University of Kansas Endowment Association is acknowledged in connection with these field studies.

walls were wet from the spray of a rushing underground river, the noise of which made conversation impossible. No bats were found. The upper cave was dry and the characteristic, ammonia odor of vampire bats was noticed as soon as we entered. Approximately 25 feet inside the mouth of the cave a typical "vampire pool" of viscous, digested blood was found. A niche in the limestone above held a solid mass of approximately 50 bats. Several were collected and proved to be the common vampire, *Desmodus rotundus murinus* Wagner. About 100 feet farther in the cave we found a room approximately 40 feet in diameter on the floor of which there were many boulders. About a dozen bats and a hundred huge, black spiders were clinging to the rough wall. The bats had the typical vampire posture; that is to say they propped themselves out from the wall by means of the thumbs. They hung by their feet and the wings were tightly folded. Their heads and bodies were lifted alertly as they eyed the light. The bats were scattered, not grouped closely as vampires usually are. The room was much used by bats, as shown by the many fecal stains on the floor, but there was no pool of liquid, digested blood. One bat (catalogue no. 17806, ♂) was shot and, in hasty examination in the beam of the flashlight, was mistakenly identified as an immature specimen of the common *Desmodus*. Therefore no effort was made to obtain additional individuals. No other species of bats were found in the cave. In spite of the difference between *Diphylla* and the common vampire, *Desmodus,* it was not until much later that the specimen was found to be a hairy-legged vampire, *Diphylla*.

On June 26, 1946, Mr. Tom Simpson of Jacala, Hidalgo, reported that there were bats in an abandoned mine tunnel just west of the Pan-American highway less than 150 yards from his hotel. The mine tunnel was cut horizontally into gravel and soft rock. A trench, dug down the center of the tunnel to remove pipes, made walking difficult. Approximately a dozen bats were present of which two were collected (nos. 17807, ♀ and 17808, ♂). Both were the soft-furred, short-thumbed *Diphylla*. Here, too, the bats were scattered rather than grouped, and droppings, for the most part, were scattered. Beneath several of the larger hollows in the roof, the stains were grouped in solid, dry patches of reddish-brown but no pools of viscous feces were present.

Near Paraje Nuevo the hairy-legged vampires were living in the Humid Tropical Life-zone at about 1,700 feet elevation. The cave was beside the Rio Atoyac in a forest of tall tropical trees,

laced with vines and hung with bromiliads and orchids. At Jacala, 4,000 feet elevation, the bats were in a zonally higher, arid valley surrounded by pine-covered mountains.

From our observations, based on three collected specimens from two localities, it would seem that *Diphylla* is less common than *Desmodus,* although more common and wide-ranging than is generally supposed. Near Paraje Nuevo, where both species were found in the same cave, *Diphylla* occupied a darker area than *Desmodus.* The mine tunnel at Jacala was also very dark. *Desmodus* was taken, however, in equally dark places elsewhere in Veracruz and in San Luis Potosi. *Diphylla* seems not to rest in clusters, as does *Desmodus,* and consequently does not form the disgusting "vampire pools" (no ammonia odor was noticed in the mine tunnel at Jacala). The altitudinal range and habitat of the two genera seem to be much the same. Davis has reported *Desmodus* from Jacala. (Jour. Mamm., Vol. 25, p. 378, November 12, 1944).

From *Desmodus,* the genus *Diphylla* can easily be distinguished by its long, soft fur, short, wide ear, short thumb lacking the distinct pad on the basal half, and the furred uropotagium. The skull is shorter, higher and wider. A small but distinct second upper incisor is present in *Diphylla* but lacking in *Desmodus.*

It is our opinion that the scarcity of specimens of *Diphylla* in collections is the result of collecting methods. A collector on entering a cave occupied by both species of vampires ordinarily would go where the bats are thickest, that is to say, above the "vampire pool." With one shot, or one sweep of a net, enough specimens of *Desmodus* are secured to occupy several hours of preparation time. The remaining *Desmodus* scatter and mingle with the *Diphylla.* Both are easily identified as vampires and ignored as the collector hunts for other species of bats. At any rate these are the conditions which the collector in Mexico finds. Nevertheless, it is among the scattered individuals that the hairy-legged vampires are to be found.

Histological Study of the Duodenum of the White Rat[1]

L. J. GIER and J. A. WHITE,
William Jewell College, Liberty, Mo.

This investigation was started several years ago as a comparative histological study of the duodena of rodents. We decided from the literature and conflicting data found in a series of squirrels, rabbits, muskrat, gophers, white rats, brown rats, and two species of mice, that it would be best to find the variations in one kind of animal under various controlled environmental conditions.

In this study, we have used litter mates of white rats for alternate environments and for the other factors observed. Slides were made of sections from paraffin, stained with Delafield's hematoxylin and eosin. Both cross and longitudinal sections were used.

The ages of the experimental animals varied from 32 days to seven months. Separate data were kept for males and females. Unmated females were compared with pregnant and lactating rats. One group was given only enough food to keep them growing slightly while another group had feed in their cage all the time. The final weight for these was 72 and 120 grams for the females and 76 and 135 grams for the males for the two groups respectively.

In the cross sections, we counted the number of villi per mm. of circumference, and for the entire circle at the pyloric end of the duodenum, down 2.2 mm. and again at 3.3 mm. from the pylorus. In the longitudinal sections we counted the number of villi per mm. from the pylorus. The amount of muscle, glandular structure, etc. present was also compared in each case.

In the cross sections, the number of villi per mm. decreases caudally from an average of 11 at the pyloric end to eight at 3.3 mm. The number was lower for females than for males of the same age. The number of villi per mm. was greater in the young than in the older rats, but the difference is comparable to the difference in size of the animals themselves. The number in the fat animals was less in the upper end of the duodenum than in those having no surplus but about the same at 3.3 mm. but the average difference was not significant statistically. The number was greater in the pregnant than in the lactating and unmated females. The diameter of the duodenum was less in the pregnant females but we did not determine if they

Transactions Kansas Academy of Science, Vol. 50, Nos. 3 and 4, 1947.

[1]This work was partially financed by a research grant from the Kansas Academy of Science.

had a longer duodenum than the other animals. The numbers found in the longitudinal section per mm. were slightly higher than in the cross section (ratio 7:6).

We found no correlation between the number of Paneth cells, goblet cells, Bruner's glands, or amount of muscle in the various sections and the factors being studied. Kammeraad[1] found goblet cells in the 20 day embryo and the anlagen of the crypts of Lieberkuhn present at birth in white rats. Lanusse-Crusse[2] found the adult conditions in the intestines had been reached by the time the young were 27 hours old. Munch[3] found no uniformity in the numbers of argentifin cells in different parts of the intestine although there was a lower average count for males than for females and decreased caudally in all. Shimizu[7] concluded the form of lacteals in the villi are determined by phylogenetic relations and also by the character of the food, but the form of the villi and their blood vessels was entirely hereditary. We found no significant differences in the lacteals. Schumann[5] found the argentifin cells in upper duodenum double in number toward the end of gestation and return to normal about 14 days after parturition.

A statistical analysis (Snedecor's variance and covariance) of the variations found showed no significance except the age-size relationship.

Literature Cited

(1) Kameraad, Adrian (Yale). The development of the gastro-intestinal tract of the rat. 2. Histogenesis of the epithelium of the stomach, small intestine, and pancreas. Jour. Morph. 70(2):323-347. 4 pl. 1942.

(2) Lanusse-Crusse. (Changes in intestinal cells at birth in mammals). Bull. Histol. Appl. Phys. et Path. 5(2):70-82. 1 fig. 1928. n.v. (Biol. Abst.)

(3) Munch, Herbert (Leipzig). Uber Menge und Vertilung der basalgekörnten Zellen im Darm der weissen Ratte. Jahrb. Morph. u Anat. Abt. II.—Zeitschr. Mikrosk. Anat. Forsch. 45(2):244-254. 1 fig. 1939. n.v. (Biol. Abst.)

(4) Sauer, Mary Elmore and Charles T. Rumble. The number of nerve cells in the mesenteric and submucous plexuses of the small intestine of the cat. Anat. Rec. 96(4):373-382. 1946.

(5) Schumann, G. Untersuchungen über das Verhalten der basalgekörnten Zellen im Darm des Meerschweinchens im Abhängigkeit von Leben salter. Geschlecht und Trachtigkeit. Zeitschr. f. Mikr.-Anat. Forschr. 45:233-243. 1939. n.v. (Biol. Abst.)

(6) Sharpes, Wynn. The histogenesis of the argentifin cells in the stomach and duodenum of the rat. Anat. Rec. 91(2):107-117. 6 fig. 1945.

(7) Shimizu, Sadao. Darmzotten und ihre Gefasse, insbesondere die Chylusgefasse der Saugetiere und des Menschen. Nr. 8 in Beitrage zur Anatomie des Lymphgefassesystems der Wirbel tiere und des Menschen (Japaner), von Takusabur o Kihara. Folia Anat. Japonica 10(2):193-227. 1 col. pl. 71 fig. 1932. n.v. (Biol. Abst.)

Spermatogenesis in *Pseudacris Triseriata*

L. J. GIER and C. C. STIGERS
William Jewell College, Liberty, Mo.

The process of spermatogenesis has been studied rather thoroughly in many animals and a generalized picture is given in most of our standard text and reference books. Just how much this lacks of showing specific conditions, however, is not suspected by the average reader or by most students as can be seen by consulting Hill "Manual of Histology and Organography" (Saunders, 7th ed., 1937) and Lambert (Introduction and Guide to the Study of Histology, Blakiston, 1938, page 392).

We are lead to believe the normal process is of a continuous nature during the normal years of the male although Rugh (Reproductive processes of the male frog, *Rana pipiens*. Jour. Exptl. Zoo. 80:81-105, 1939) states the "mature and functional sperm are available at any time of the year between September and the normal breeding season" in *R. pipiens* and that there was a "great reduction in size of the testes of *R. fusca* after breeding." This statement would indicate a probable reduction in activity.

In April, 1944, while studying microtechnic, specimens of *Pseudacris triseriata* were taken from a marshy area on the William Jewell College campus. A testis smear stained with gentian violet showed a multitude of deeply staining crescent shaped bodies which were later recognized as sperm. Other frogs of this species were taken for further studies that spring and again in 1946. Some were dissected before amplexus and others after mating and the testes of all were sectioned in paraffin. We were unable to follow the cycle throughout the year due to a scarcity of specimens but a fairly complete series was studied during March and April.

All frogs studied before or during amplexus showed the tubules packed with sperm and some spermatocytes but those killed after mating, up to April 25, had no sperm or spermatocytes and the interstitial cells showed some deterioration. The last evidence of mating was March 28.

These studies indicate that all or nearly all of the spermatogenic epithelium of all parts of all tubules was active during the time immediately preceding mating; that practically all spermato-

cytes underwent maturation at this time; and that there was a considerable reduction of tissue. This would indicate a reduction in size of testes (which were not measured in toto) after mating with the probable result that it would be some time before the testes could produce more sperm, if ever.

Censusing Wildlife*

H. LEO BROWN
Ashland, Kansas

Censusing is the first step in game management and it is the scarcity of animals or the over abundance of animal numbers that awakens one to the needs of censusing wildlife.

The technician must select the method of censusing that will give the best results for the particular game count. The observer keeps in mind: time alloted, the number of persons assisting, the season, the topography, the animal or animals involved and the habits of the species. It would be somewhat difficult to get a line count on nocturnal species, therefore trapping or some other method of censusing would have to be used.

The technique used may be by direct enumeration of whole areas or samples of areas. It may be by ratio based on trapping and banding and then later recapturing. The later method has been used quite extensively and is probably the most widely used census method practiced today. This method has been used mostly on migratory birds and especially migratory game birds. Direct observation of the condition or density of population through the use of indices has been used to some advantage.

All the wildlife census work should be done under the supervision of a trained wildlife technician. Unexperienced and untrained men do not collect reliable data. One would not think of consulting a common laborer in regard to illness such as appendicitis. Even in trying times we have our pick of the best of doctors who are well trained in their profession.

The main purpose of a game census is to invoice and see what the wildlife is doing from a business standpoint, as one would check banking interests or livestock upon a ranch. We are interested in wildlife for monetary and recreational purposes. The abundance or scarcity revealed by a game census has much to do with checking predators and opening and closing of the seasons, and helps in preserving species that are approaching depletion. It has turned the minds of people to scientific management of game birds and mammals similar to that applied to domestic livestock.

Mass data usually gives most accurate results in estimating game population. It is a time consuming method and requires many

Transactions Kansas Academy of Science, Vol. 50, Nos. 3 and 4, 1947.
*Contribution No. 57, Dept. of Zoology, Fort Hays Kansas State College, Hays.

hours of hard work, but there has been no substitute for mass data. The methods in collecting mass data are varied and can be applied to all species of birds and mammals with accuracy.

There are five methods of censusing used quite extensively. They are the spot census, the maze census, the gridiron census, random census, and the line census. These methods can be used in several ways besides flushing the animals. One can use them in den counts, scat counts, tracks and nests, which serve as indicators to animal numbers.

The use of owl pellets is a very good indicator for the number of species of rodents and other small animals on an area. In a barn owl nest 1223 skulls were collected from the pellets by the writer. Eleven species of animals were represented: Microtus 965, Perognathus 95, Peromyscus 55, Reithrodontomys 35, Blarina 26, Lagomorph 16, Cryptotis 14, Aves 12, Mus 8, Onychomys 5 and Dipodomys 1.

Game drives and circle hunts have been used in hunting rabbits and coyotes quite extensively. Game drives have been conducted in the Eastern part of the United States to census deer; also antelope, elk and deer have been censused in the western part of the United States. This method requires a large number of people and is somewhat expensive.

Brown (1947), took population counts of jack rabbits and cottontail by dragging a long wire tied to the rear bumpers of two cars for flushing these animals in open prairie country.

The population of large game animals and fur bearing animals may be estimated by studying the tracks. In observing tracks one can count the numbers and can determine if the animals are adult or young by the size of the tracks. If one becomes skilled in the art of tracking the genus can be told with much accuracy. By observing the tracks in the snow or mud one can observe denning habits and the territories in which they feed. The bobwhite is one of the easiest of the game birds to census by tracks. The European partridges have similar habits to the bobwhite and the population can be determined by the use of track counts.

Bobwhites were censused by Leopold (1931) in the north central states by flushing and counting with the use of a good bird dog. He also asked farmers and hunters to estimate the number of quail on a given area. This method was not reliable as it was all guess work, without any scientific basis for their conclusions. He however did get some reliable results from farmers and hunters on the

exact numbers they had seen on a local farm or given area. Leopold likes the covey count for quail censusing. The quail are local birds with a small cruising radius compared to our other game birds. The European partridge is counted by the same method with accuracy. The prairie chickens have a large cruising radius but tend to flock which makes counting easy. This is not true of the pheasant, with a cruising radius similar to that of the prairie chicken. Leopold says the pheasant is the most difficult of all the North American upland game species to census. They are segregate birds and do not have the flocking habits of most game birds.

The author has censused pheasants by track counts and by observing the shelters, such as thickets and tall weeds where the birds are seeking shelter in severe snow storms. Counts must be made during the storm or soon after, as the birds scatter again soon after the storm. It was found that on eight farms in Jewell County, Kansas, there were flushed 200 pheasants on approximately 3,200 acres. This would make one pheasant to every 16 acres.

Ringneck pheasants were successfully county by Dr. Hendrickson and Dr. Bennett in 1938, by driving in a car along a dirt or gravel road at the rate of 20 miles per hour at sunup or soon after. Eight to ten birds to the mile will represent one bird to four or five acres. Two birds to a mile indicate a population of one bird to seven or nine acres. One bird to the mile indicates a population of one pheasant to eighteen acres.

Cole in 1920 used for census methods the trapping and banding of animals. for population counts and then recaptured them. This is a time consuming method but is one of the best for studying migratory birds.

Lincoln (1930), has been the pioneer in bird banding, especially for migratory water-fowl. Today this is one of the widely used and most popular methods of censusing. Migratory water-fowl have led the field in bird groups. The tagging of muskrat, deer, elk, beaver, rabbit and skunk has been used with considerable success.

The Biological Survey has used bag record for most of the large game on the federal refuges. It is used extensively at the present time for the wild turkey, deer, elk, bear and other large game animals. Several states have used bag record for making animal counts. The Biological Survey has used the line count and the spot count system to a great extent. These two methods are expensive and require a large number of people to assist in the drives. The airplane census method is replacing the spot and line

census methods for large game animals and has been tried in the east on the deer with good success. This method has the advantage of covering a wide range of territory with less cost and labor. It will no doubt be used to a great extent by the Biological Survey for censusing large game animals in the next few years.

King, of Minnesota (1937), has studied the ruffed grouse population by counting the young in a clutch. We found the June broods had a much higher mortality than the July and August hatched chicks. The large decrease of the early hatch in June was due to the cold weather and the chicks being chilled.

The mourning dove at Lewis, Iowa, conducted by McClure (1939), gives an interesting method for one person to use in studying bird life. He used the spot and random census systems for his study of dove population. The counting of nests was of value in computing populations. The cooing habit of the male dove was a good indicator as to the number of doves on the area he studied.

The Mearns cottontail has been studied extensively by Dr. Hendrickson, (1939). He suggests the counting of rabbits by checking on the sets made in the snow and grass. The counting of urinal spots on the snow are indicators of rabbit population. The trapping of rabbits was not so successful and was slow for the estimation of rabbits on large territories and areas located considerable distances apart. For this method the traps must be checked regularly to keep specimens from freezing in severe weather or starving from lack of food. The method used to the best advantage was the pellet (scat) count system. An area of one or more acres can be used in this study. At intervals of 25 feet the pellets are counted from an area of one square foot. It is estimated that 0.52 pellets to a square foot is an index for one cottontail to an acre of feeding range.

Brown (1947), conducted pellet counts in a mixed prairie area near Hays, Kansas, and found that a pellet count of 0.54 jack rabbit pellets per square foot indicated one jack rabbit per acre and that 0.50 cottontail pellets per square foot represented approximately one cottontail per acre. This method has been used in Arizona to census jack rabbits.

The taking of a game census is a professional art for one who is trained in wildlife work. The measuring for the response of game populations to changes, deliberate or accidental, in their environment is the big task confronting the wildlife technicians. Continuous censusing is the pivot post of success or failure in the conservation of wildlife.

Literature Cited

ADAMS, HENRY E. 1938. Deer Censuses and Kill Records of the Lake States. Transactions of the 3rd North American Wildlife Conference.

ASHBROOK, FRANK G. 1936. Marking Wild Animals for Identification. U. S. Dept. of Int. Bureau of Biological Survey. B. S. No. 57.

BENNETT, L. J. and GEO. O. HENDRICKSON. 1938. Censusing the Ringneck Pheasant in Iowa. Trans. of the 3rd North American Wildlife Conference.

BROWN, H. LEO. The Distribution of the White-tailed Jack Rabbit in Kansas. Trans. of Kansas Academy of Science, Vol. 43.

BROWN, H. LEO. 1947. Rodent Activity in a Mixed Prairie Near Hays, Kansas. Trans. of Kansas Academy of Science, Vol. 48, No. 4.

BROWN, H. LEO. 1947. Coaction of Jack Rabbit, Cottontail, and Vegetation in a Mixed Prairie. Trans. of Kansas Academy of Science, Vol. 50, No. 1.

HENDRICKSON, GEO. O. 1939. Inventory Methods of the Mearns Cottontail. Trans. of 3rd North American Wildlife Conference.

KING, RALPH T. 1937. Ruffed Grouse Management. Journal of Forestry. Vol. 35, No. 6.

LEOPOLD, ALDO. 1931. Report on a Grouse Survey of the North Central States. Sporting Arms and Ammunition Manufacturing's Institution, Madison, Wisconsin.

LINCOLN, F. C. 1930. Calculating Water-fowl Abundance on the Basis of Bird Banding. U. S. Dept. of Int. Circular No. 118.

MCCLURE, ELLIOT. 1939. Habits of the Mourning Dove at Lewis, Iowa. Research Bulletin. Ames, Iowa.

PIERCE, RANDALL E. and LOGAN J. BENNETT. 1939. Censusing Ringneck Pheasants in Pennsylvania. Trans. of the 4th North American Wildlife Conference.

RUFF, FREDERICK J. 1939. Region 8 Technique of Wildlife Inventory. Trans. of the 4th North American Wildlife Conference.

STEBLER, A. M. 1939. The Tracking Technique in the Studying of Large Predatory Mammals. Trans. of the 4th North American Wildlife Conference.

More or Less Potency of Genes[1]

ROBERT K. NABOURS and FLORENCE M. STEBBINS
Kansas Agricultural Experiment Station, Manhattan

In the matings of *Apotettix eurycephalus* Hancock, wherein both parents were heterozygous for a lethal, an average of one-fourth of the offspring died at the stage approximately 4 days before time for hatching. If there were lesions or other malformations in the embryos that failed to hatch, they escaped detection. There were approximately 800 matings in which one or both of the parents were heterozygous for the lethal. A preliminary account has been published by Nabours and Kingsley, 1934. The full data are to appear in a forthcoming Kans. Agric. Expt. Station Technical Bulletin, by Nabours and Stebbins.

A conspicuous feature of this death-causing gene was connected with its potency. The individuals that were heterozygous for it exhibited a viability superior to that of the sibs homozygous for the normal allele. Not only did such heterozygous lethals reach the stage of 3-5th instars when they were recorded in significantly larger numbers, but they appeared to be more vigorous, better feeders and breeders. The following table indicates the higher viability of the heterozygous lethals over their sibs homozygous for the normal allele:

Table 1.

	Type of Mating	Number of Homozygotes +/+	Number of Heterozygotes le/+	Deviation from expected ratio	D/PE
	le/+ X le/+	4654	9872	188.0	4.91
	le/+ X +/+	8744	9288	272.0	6.01
Controls	T/+ X +/+	5985	6001 T/+	8.0	.22
Controls	K/+ X +/+	4781	4914 K/+	66.5	2.003
Controls	G/+ X +/+	4329	4382 G/+	26.5	.84
Controls	A/+ X +/+	29130	29345 A/+	107.5	1.32

The first two items of the table have been augmented by the data which accrued subsequent to those available in 1934 (loc. cit.). The locus of the lethal was between closely linked loci of color patterns so that its presence was attested in all results employed. The controls are the same as those published by Nabours and Kingsley (1934). In the controls, three dominant color patterns, T, K and G, are compared with their homozygous recessive alleles. In addition, last item in the table, a number of dominants, designated collectively as A, are compared with their recessive alleles.

Transactions Kansas Academy of Science, Vol. 50, Nos. 3 and 4, 1947.
[1]Contribution No. 248, Department of Zoology.

It appears that the death-dealing gene in double or homozygous quantity and potency provided for some sort of deleterious activation or retardation which caused death at a specific stage four days before time for hatching; whereas the amount and efficacy of the single or heterozygous gene functioned favorably to vigor and viability beyond that available for the sibs homozygous for the normal allele.

This phenomenon is not without parallel in other organisms: Rasmusson, 1927; Karper, 1930; Robertson, D. W., 1932, and with Austin, 1935; Gustafsson, 1938 and 1946; and others have secured comparable results in various plants such as *Pisum, Sorghum,* and barley. Gustafsson (1946) has presented a comprehensive review of the work of the various investigators. He concludes that "mutations lethal in homozygous conditions may increase viability when they occur in the single dose" and that "vigor may also be affected in a general sense; in some plants the reproductive capacity is increased along with properties such as length of culm, length of head, and ability of tillering."

It is suggested that there is nothing inherent in lethals, per se, that provides for an occasional one to function in heterozygous amount and potency discretely favorable to vigor and viability. In contrast, certain lethals, such as 'creeper' in fowls, are distinctly deleterious in the heterozygous quantity and consequence. No particular lethal, as among genes in general, is probably exactly like any other with respect to its effect in the single or double amount. There are undoubtedly many kinds and degrees of potency, ranging from the favorable one in the grouse locust *A. eurycephalus* and those in plants cited by Gustafsson to 'creeper' in fowls and others that barely allow the heterozygous bearers to propagate and survive.

Many, if not the majority of genes, whether lethal, semi-lethal, or those entirely extraneous to properties of vigor and viability, logically should function on the general principle of a different effect in the single from that in the double amount and potency. There are some good examples in the relative amounts and effects of special pigments provided by the respective genes for conspicuous dominant color patterns in the grouse locusts.

In *A. eurycephalus,* the gene Y produces a large, pigmentless white spot on the pronotum. The gene for the pattern T provides for a dense, red or mahogany pigment in the hypodermis of the pronotum. These genes have a linkage of approximately 6 points and, therefore, it is convenient to compare the respective n and 2n

amounts of T pigment and the n and 2n degrees of clearness of the Y spot.

A single gene of each, Y/T, shows the white spot, Y, plainly modified by the dark, red pigment of T. The Y/YT, doubling of the gene for the Y pattern, with the single or heterozygous T, produces a conspicuous Y spot with a mere tinge of the red of T showing in it. The YT/T, doubling of the pigment-producing gene T, with the single or heterozygous Y, considerably obscures the white spot, with the red pigment obviously increased (Nabours, 1925, plate I). A comparable result was obtained in an experiment with the pigments in the pronota of *Paratettix texanus* (Nabours, 1914).

Summary and Conclusions

The principle of less or more manifestation of the single and double amounts and effectiveness of genes is not only logical but appears to have been experimentally well-established. Part of the support is found in the three clearly recognized degrees of lethal as follows: 1. The regular, recessive lethals which are apparently, really doubtfully, neutral in the n amount and effect. 2. Those manifestly deleterious in their effects in the n quantity ('creeper', et als.). 3. Those distinctly favorable to vigor and viability in the n amount and results (*A. eurycephalus* and plants cited). To these should be added the striking differences in amount of pigment provided by the respective n and 2n genes for patterns in T and Y in *A. eurycephalus* and + (old A) and B in *P. texanus* discussed above, and many other pattern combinations in these and other species.

Literature

(1) Gustafsson, A. 1938. Studies on the genetic basis of chlorophyll formation and the mechanism of induced mutating, Hereditas, V. 24, 33-93.
(2) ———. 1946. The effect of heterozygosity on variability and vigour, Hereditas, V. 32, 263-286.
(3) Karper, R. E. 1930. The effect of a single gene upon development in the heterozygote in Sorghum, Jour. Hered., V. 21, 187-192.
(4) Nabours, Robert K. 1914. Studies of inheritance in *Orthoptera* I. *Paratettix texanus,* Jour. Gen., V. 3, 141-170.
(5) ———. 1917. Studies of inheritance in *Orthoptera* II and III. *Paratettix texanus* and a mutant, Jour. Gen., V. 7, 1-54.
(6) ———. 1923. A new dominant color pattern and combinations that breed true in the grouse locusts, Genetica, V. 5, 477-480.
(7) ———. 1925. Studies of inheritance and evolution in the *Orthoptera* V. The grouse locust *Apotettix eurycephalus* Hancock, Kans. Agric. Expt. Sta. Tech. Bull. 17, 1-231.
(8) ———. 1929. The genetics of the *Tettigidae,* Bibl. Gen., V. 5, 27-104, Martinus Nijhoff, The Hague.
(9) ———. 1937. Methoden und ergebnisse bei der Zuchtung von *Tetriginae,* Handbuch der biologischen Arbeitsmethoden, Abt. 9, Teil 3, 1309-1365.
(10) Nabours, Robert K. and Laurel Kingsley. 1934. The operations of a lethal factor in *Apotettix eurycephalus,* Gen., V. 19, 323-328 (Abstract in Rec. Gen. Soc. of Am., No. 2, 1933).

(11) Rasmusson, J. 1927. Genetically changed linkage values in *Pisum,* Hereditas, V. 10, 1-152.
(12) Robertson, D. W. 1929. Linkage studies in barley, Gen., V. 14, 1-36.
(13) ———. 1932. The effect of a lethal in the heterozygous condition on barley development, Colo. Agric. Expt. Station Tech. Bull. 1, 1-12.
(14) Robertson, D. W. and W. W. Austin. 1935. The effect of one and of two seedling lethals in the heterozygous condition on barley development, Jour. Agric. Res., V. 51, 435-440.
(15) Robertson, W. R. B. 1931. Hybrid vigor. A factor in *Tettigid* parthenogenesis, Am. Nat., V. 65, 165-172.

The Similar Effect of Rations Containing Butter Fat or Corn Oil Upon the Maze-Learning Ability of Rats[1,2]

D. B. PARRISH, O. W. ALM, E. ROBERTA SHIMER, and J. S. HUGHES
Departments of Chemistry and of Education, Kansas State College, Manhattan

Many studies have been reported in which growth was the criterion for determining the nutritive value of a food. Recent advances in the science of nutrition indicate that the value of a ration cannot be judged alone in terms of gain in weight or of increase in body length. Food may have a direct or indirect influence on other vital processes. One of the most challenging problems, which is as yet incompletely elucidated, is the influence of food on mental ability. Relatively few experimental investigations of this type have been reported. However, studies have been made of the effect of vitamins, of minerals, of phospholipids, and of amino acids upon the ability of the laboratory animals to perform certain tasks such as learning to run a maze. Investigators interested in work of this type should consult references given by Kreezer ('42) and by Fritz ('34). Among the recent studies are those of Alm and Whitnah ('41), Zimmerman and Ross ('44), and Albert and Warden ('44).

The use of vegetable fats in the place of animal fats in human nutrition has aroused considerable interest in the comparative nutritive value of these materials. Boutwell et al. ('43, '45) have reported that on a high-lactose ration, weanling rats made greater gains in weight when fed butter fat than when they received vegetable oils. These findings have been supported in part by the work of Parrish et al. ('46) using corn oil. On the other hand, Deuel et al. ('44, '45) and Zialcita and Mitchell ('44) did not find corn oil to have an inferior nutritive value, but their rations did not contain added lactose. This present study was undertaken to broaden our knowledge of the nutritive value of vegetable and animal fats by investigating the effect of rations containing corn oil and butter fat upon the maze-learning ability of rats.

METHOD

Weanling male rats were fed ad libitum on the experimental rations for three to six weeks. Following this period, the rats were

Transactions Kansas Academy of Science, Vol. 50, Nos. 3 and 4, 1947.

[1]A cooperative project. The nutrition work is contribution No. 312, Department of Chemistry, Agricultural Experiment Station; the psychological work was done under the direction of O. W. Alm, Department of Education.

[2]Supported in part by a grant from the American Dairy Association.

given a series of learning trials on two different mazes to determine whether the rations had an effect upon maze performance.

Animals, Rations, and Feeding Schedule

All rats were obtained from Sprague-Dawley, Madison, Wisconsin; 40-45 gm males, weaned at 20 days of age were specified. The rats used for experiments I and III were fed during the growth period in laboratories at Wisconsin University. The rations used for these groups were of the same formula as rations for the rest of the groups of animals but were prepared in the Wisconsin laboratory using ingredients procured in that locality.[3] These rats were shipped by express without food during transit, and except for a loss of weight, arrived in good condition. A transportation delay made it necessary to use rations prepared locally for feeding rats on experiment III after they were received. Animals for the other experiments were shipped direct from the dealer to this laboratory and appeared normal on arrival.

The rations consisted of ether-extracted skim milk powder, 50 parts; lactose, 20 parts; and either butter fat or corn oil, 30 parts. Minerals and fat soluble vitamins were added. For further details concerning the rations, feeding, and care of the animals during the growth period, consult the previous publication of Parrish et al. ('46). Table 1 presents the principal facts concerning the rats used on the various maze experiments.

Table 1.—Facts Concerning Rats and Rations used in the Maze-Learning Studies.

Expt. No.	No. of rats[1]	Source of ration[2]	Where fed before maze running[2]	Age at various stages: Placed on expt., fed ad libitum	Start of restricted feeding	Start Maze B	Start Maze C	Finish Maze C
				Days	*Days*	*Days*	*Days*	*Days*
I	12	Wis.	Wis.	21	66	69	88	103
II-A	12	Kan.	Kan.	21	63	65	80	91
II-B	12	Kan.	Kan.	21	43	45	62	72
III	24	Wis. / Kan.[3]	Wis.	21	43	46	61	71
IV-A	24	Kan.	Kan.	22	43	45	55	65
IV-B	12	Kan.	Kan.	22	64	67	77	88
IV-C	12	Wis.	Kan.	22	64	67	77	88

[1]One-half of the rats on butter fat and one-half on corn oil rations.
[2]Rations are designated as Wis. or Kan., depending on whether they were mixed in the laboratory at Wisconsin University or at Kansas State College. Similar designations are used for the place at which the rats were fed before maze-running.
[3]Kansas rations were fed after 43 days of age.

Since small amounts of the respective rations were used as bait during the learning tests, the daily rations were cut to 3-5 gms.

[3]The authors are indebted to R. K. Boutwell and co-workers for cooperation on this phase of these experiments.

for two or three days before starting the learning trials. Following the period during which restricted rations were offered, the rats were fed each day after running the maze. Each animal had access to the same amount of food (5-7 gms), but any food not eaten within a 30-minute feeding period was removed. Continual growth was possible because of the high energy content of the rations, but the restricted feeding resulted in the rats being well motivated for the maze running.

No evidence of gross deterioration of the rats fed either feed was noticed during these studies—their general condition and appearance were good. Some of the animals were observed to have a mild alopecia of the posterior part of the abdomen. The condition was somewhat more prevalent than found during the growth studies (Parrish et al., '46); and, while the condition was observed on rats fed both rations, a few more of these animals were from the corn oil than from the butter fat groups. The increase in the number of rats thus affected may have resulted from a deficiency in the ration, which was made more acute by restricted feed consumption during the maze studies. It was unnecessary to discard any animal because of an abnormal condition.

Mazes and Learning Procedure

The mazes used were an enclosed box maze and an elevated multiple-T maze, essentially the same as Mazes B and C used by

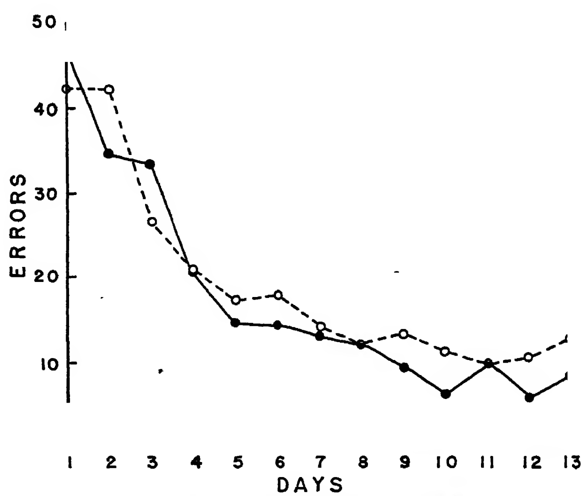


Fig. 1.—Average errors made per day on experiments II-A, Maze B, by rats fed the corn ration (----) and the butter fat ration (——).

before beginning the regular trials. Three rats at a time were placed in the maze and allowed to explore and take their time arriving at the food box. Four such trials were given on each maze just previous to the regular individual trials. This procedure seemed adequate for adjusting the rats so that they ran the mazes without undue delay. In experiments I, II-A, and II-B, 60 individual trials were given on Maze B, five trials being carried out each day. Since it was discovered that on this maze the rats showed no appreciable improvement in scores after 30-40 trials, only 40 trials were used in later work. (Typical results are shown in figure 1; 30 trials were completed in the first six days). Twenty-six trials were given on Maze C, three trials on each day except one. Records were kept of both the number of errors made and the time required for the rat to reach the food box.

As nearly as possible all animals were handled under identical conditions. Maze running and feeding were done at approximately the same time each day. Alternating from day to day, first the corn oil and then the butter fat groups were allowed to run the maze first. Except in experiment I, all rats were run once through the maze before any were given a second trial, all a second before any a third trial, etc.

Motivation and Food Preference

Equal motivation in maze running will not be obtained when small quantities of the rations are used as bait if one ration is distasteful or if it produces some other physiological condition which causes the rat to reject it. Under such conditions maze performance cannot be expected to give estimates of learning ability. The food preference of some of the rats used in the present experiments has been reported (Parrish et al., '46). In this earlier study the rats generally showed a preference for the food they previously had received. The data indicated rather clearly that hungry rats previously fed the corn oil ration did not select a ration containing butter fat more frequently than one containing corn oil. Further, it was noted that many of the butter fat group freely selected the corn oil ration, and that frequently the rats were content to sample first one and then the other ration. In the maze studies it was found that almost invariably the rats went immediately to the food cup and commenced eating as soon as they arrived at the end of the maze. In view of the foregoing facts, it would seem that either ration served adequately as bait for the maze-learning studies.

Alm and Whitnah ('36). In each experiment Maze B was used first, followed by Maze C. Group orientation trials were given

Results and Discussion

Both the time and error scores were kept on each maze; thus four different sets of data are available for judging the effect of the ration upon the learning ability of the rats. The *t* test (Fisher, '36) was used for analyzing the data. The results are summarized in table 2. (The number of rats in each group and other pertinent data may be found by reference to table 1). The *t* was not significant (a probability of 0.05 or less) in any of the individual experiments using Maze C. With Maze B, only the differences in the time

Table 2.—Results of Maze-Learning Tests of Rats Fed Rations Containing Corn Oil or Butterfat.

Experimental groups	Errors: Average per rat[1]	Errors: *t*	Errors: P[2]	Time in seconds: Average per rat[1]	Time in seconds: *t*	Time in seconds: P[2]
			Maze B			
I						
Corn oil	157.2			402.2		
Butter fat	125.8	1.79	.12	359.5	1.0	.35
II-A						
Corn oil	137.0			349.3		
Butter fat	131.3	0.57	.55	344.6	.15	.88
II-B						
Corn oil	161.0			474.0		
Butter fat	132.2	2.2	.06	325.2	3.29	.02
III						
Corn oil	125.3			263.2		
Butter fat	144.4	1.0	.32	294.0	1.04	.32
IV-A						
Corn oil	143.9			306.8		
Butter fat	148.3	.19	.85	319.9	.32	.75
IV-B						
Corn oil	154.7			563.0		
Butter fat	127.0	1.9	.12	380.3	3.65	.02
IV-C						
Corn oil	145.3			519.4		
Butter fat	137.0	.48	.65	422.9	.95	.38
			Maze C			
I						
Corn oil	88.7			952.0		
Butter fat	88.8	.01	.98	1096.4	.65	.55
II-A						
Corn oil	117.8			1602.2		
Butter fat	117.0	.04	.96	1169.1	1.50	.17
II-B						
Corn oil	125.0			1465.3		
Butter fat	93.5	1.08	.31	900.8	1.69	.15
III						
Corn oil	52.3			496.9		
Butter fat	67.6	1.25	.25	573.0	1.18	.27
IV-A						
Corn oil	63.9			683.5		
Butter fat	57.3	.71	.52	579.0	1.26	.26
IV-B						
Corn oil	97.5			1042.5		
Butter fat	90.2	.25	.82	984.3	.29	.77
IV-C						
Corn oil	91.3			995.4		
Butter fat	68.8	1.15	.30	940.0	.36	.73

[1]Average for 40 trials on Maze B and 26 trials on Maze C.
[2]Probability. Some values obtained by interpolation from tables.

scores and the error scores for experiment II-B and the difference in the time scores for experiment IV-B were significant. By Fisher's method ('36) of combining the probabilities from independent tests of significance, the probabilities for the error and time scores on Maze B were, respectively, 0.20 and 0.07; and on Maze C, 0.50 and 0.45. From the statistical treatment it is concluded that, although some differences were found in the scores made by rats on the two rations—a difference most frequently favorable to the butter fat group—, rats fed both rations exhibited similar abilities to run the mazes.

A study of the differences in the results obtained with the two mazes suggests that there may have been a tendency for the fats to cause differences in maze-learning ability of younger rats which were overcome in later trials (Maze B was used before Maze C) or that Maze B requires a greater degree of discrimination than Maze C.

Since much of the interest in fat nutrition has centered around the diets of the very young, placing the rats upon the experimental rations soon after birth is suggested as the next phase of the problem that should be investigated. By the time the rat is weaned it has received natural milk fat in relatively large amounts. If lipids have specific effects upon the development of the nervous system, a major part of the lipid requirement for this purpose possibly may be met before weaning, since it is known that most of the growth and medullation of brain tissue occurs by the 20th day after birth (Koch and Koch, '13).

While it was found that the experimental rations employed in this study caused no significant differences in the maze-learning ability of rats, the results should not be interpreted broadly as applying to other types of diets containing these fats. The differences found in the various growth studies, which previously have been cited, clearly suggest such caution.

Summary and Conclusion

A method is described for testing the effect of different rations upon the maze-learning ability of rats.

Although differences were observed in the average time and error scores made by rats receiving butter fat and corn oil in a lactose-dried milk ration, the differences as a whole were not found to be significant; thus both rations had a similar effect upon maze-learning ability.

Literature Cited

ALBERT, K. E., and C. J. WARDEN. 1944. The level of performance in the white rat. Science, vol. 100, p. 476.

ALM, O. W., and C. H. WHITNAH. 1936. The relationship between brain lipids and learning ability of albino rats. J. Genet. Psychol., vol. 49, p. 389.

———. 1941. The brain minerals and learning ability of albino rats. J. Genet. Psychol., vol. 59, p. 51.

BOUTWELL, R. K., R. P. GEYER, C. A. ELVEHJEM and E. B. HART. 1943. Further studies on the comparative value of butter fat, vegetable oils and oleomargarines. J. Nutrition, vol. 26, p. 601.

———. 1945. Studies on the interrelation of fats, carbohydrates, and B-vitamins in rat nutrition. Arch. Biochem., vol. 7, p. 143.

DEUEL, H. J., JR., and E. MOVITT. 1945. Studies on the comparative nutritive value of fats. V. The growth rate and efficiency of conversion of various diets to tissue in rats weaned at 14 days. J. Nutrition, vol. 29, p. 237.

DEUEL, H. J., JR., E. MOVITT, L. F. HALLMAN and F. MATTSON. 1944. Studies of the comparative nutritive value of fats. I. Growth rate and efficiency of conversion of various diets to tissue. J. Nutrition, vol. 27, p. 107.

FISHER, R. A. 1936. Statistical methods for research workers. Oliver and Boyd, London, 339 pp.

FRITZ, M. F. 1934. A classified bibliography on psychodietetics. Psychol. Monog., vol. 46, no. 2, 53 pp.

KOCH, W., and M. L. KOCH. 1913. Contributions to the chemical differentiation of the central nervous system: III. The chemical differentiation of the brain of the albino rat during growth. J. Biol. Chem., vol. 15, p. 423.

KREEZER, G. L. 1942. Techniques for the investigation of psychological phenomena in the rat. (Chapter 10, p. 199, The Rat in Laboratory Investigation. Griffith, J. Q., Jr., and E. J. Ferris, Ed. Lippincott, Philadelphia 1942. 488 pp.)

PARRISH, D. B., E. R. SHIMER and J. S. HUGHES. 1946. Growth and food preference of rats fed a lactose-dried milk ration containing butter fat or corn oil. J. Nutrition, vol. 31, p. 321.

ZIMMERMAN, F. T., and S. ROSS. 1944. The effect of glutamic acid on learning ability. Arch. of Neurology and Psychiatry, vol. 51, p. 446.

ZIALCITA, L. P., JR., and H. H. MITCHELL. 1944. Corn oil and butter fat essentially equal in growth-promoting value. Science, vol. 100, p. 60.

Licensing Chemists and Chemical Engineers

O. W. CHAPMAN
Kansas State Teachers College, Pittsburg

Chemical engineers, with other engineers, are now licensed in 47 states and 3 territories. Recently there has been agitation to secure the passage of bills in state legislatures to license chemists. The movement has been vigorously opposed, the resulting controversy being not unlike that preceding the enforced licensing of physicians. Two other proposals have also been made—registration and certification.

The movement to require licensing appears to have been instigated by individuals who are dissatisfied with their professional and economic status. Many others oppose the movement because they are satisfied with present conditions, or because they feel it would be unwise, or because of confusion regarding the meaning of licensing. There should be an agreement on definitions of the schemes proposed.

As proposed, state licensing would constitute legal permission to do something otherwise unlawful. The State would be empowered to define certain acts which, if performed indiscriminately, would jeopardize the life, health, or property of the public, and make these acts illegal. Boards would be established to set up certain minimum requirements, which, when met, would entitle individuals to a license which would be prima facie evidence at law of the individuals competency to perform the prescribed acts.

Legal registration frequently is used synonymously with licensing. When a distinction is made, registration is regarded as permissive, whereas licensing may be compulsory. Registration is a statement by an individual of his education, experience, and qualifications; licensing is a legal permission to perform certain acts.

National certification is a plan whereby a national board would be empowered to examine applicants and certify those who pass the examinations. The plan is permissive, but it is believed that a certificate would give so much prestige that all chemists would apply.

A number of arguments have been advanced for and against the plans, and many articles and letters, led by Egloff for, and Parsons against, have appeared in chemical publications. A study of the debate indicates a lack of sound basis for the arguments of both

sides; rather they appear to be based upon personal feeling. To illustrate: The Hancock report is cited for evidence, yet only about 2,000 chemists replied to the questionnaire; polls of a few local sections of the A.C.S. were made. However, the A.C.S. has just completed a poll of its over 50,000 members. Results of such a canvass should be representative.

The arguments regarding state licensure may be divided into two groups: (1) advantages to the public, and (2) advantages to the profession. Backers of the plan maintain that life, health, and property will be protected by eliminating charlatans. They point especially to those making clinical analyses, sanitary analyses, persons working with drugs, foods, cosmetics, and construction materials, where incompetent analysts might cause direct injury to the public. They also point out that firms employing chemists will be protected from hiring incompetent individuals. Opponents of the plan question the value of licensing because only those persons in responsible charge of work need be licensed, so most of the actual work might be done by poorly trained persons. It is maintained that most companies employing chemists are as competent to judge the qualifications of prospective employees as are licensing boards.

It is possible that licensing might help chemists themselves. It is believed by many that the plan would lead to a real profession of chemistry, lifting it out of the skilled trades classification. Egloff points out that the Federal and New York Civil Service Commissions both refused to recognize chemistry as a profession, although the decision was vigorously protested by the A.C.S. In the federal census, chemistry was listed as a trade, not a profession. Opponents, on the other hand, claim that a license will give standing to no one who has standing. Nydick points out that licensing does not make a profession. Plumbers, bartenders, beauty operators, and others are licensed, but that does not make professions of their trades.

Another controversial point is the status of chemists when called upon to testify in court trials. Proponents of licensing maintain that the testimony of licensed physicians is taken without question, and cite an instance in which the testimony was ruled valueless because he was not licensed. Nydick, a lawyer as well as a chemist, states that a witness need not be licensed in order to qualify as an expert, and that even medical witnesses do not necessarily have to have an M.D. degree or license to qualify.

Marked improvement in college and university courses has followed compulsory licensing in medicine and law. That the same

would be true of courses in chemistry is the belief of advocates of licensing. Parsons and others feel that the approval of schools by the A.C.S. is accomplishing this objective at least as effectively as would any other plan.

Unionization of chemists is of concern to both factions. Proponents of licensing feel that their plan will decrease the number joining trade unions either by choice or coercion. Parsons maintains that more licensed engineers have joined unions than have non-licensed chemists.

Proponents of licensure appear to be attempting to lure to their point of view younger chemists by the prospects of attaining better economic conditions. There seems to be no tangible evidence that such improvement would result, as it is known there exists a wide range in the incomes of individual doctors, lawyers, dentists, and engineers.

There are a number of other points brought out by the opponents of state licensing. These include the contention that if all chemists are compelled to license that it will amount to regimentation; the fees will amount to a .sizable tax on chemists; different laws in different states will create a barrier to chemists; such laws are of value only to consultants who make up only 5 per cent of the A.C.S. membership; and possible favoritism of boards may actually result in decreased public protection. The "grandfather" clause is considered a weakness in proposed laws, but is always included in proposed legislation because it is doubtful if any bill would be adopted which did not contain such exemptions.

Other arguments for licensing, perhaps of less importance, include: More recognition of the profession by the public; higher ethical standing and professional integrity; protect consultants from paying unincorporated taxes, and promote unity within the profession.

Points of contention regarding legal registration are much the same as for state licensing, and so will not be considered separately here.

A plan for national certification has been proposed by Sperry. He feels that all is not well with the chemical profession, and that many chemists are dissatisfied with their professional and economic status. After a study of the Ohio and Illinois bills, Mr. Sperry has concluded that neither will accomplish the principal benefits to chemists claimed for licensing, because under them only a small proportion of chemists would be compelled to qualify.

The substitute plan proposes that the chemical profession establish a system of certification similar in principle to that of the medical profession. A National Board of Examiners would be established empowered to give thorough comprehensive examinations to graduates in chemistry. Certificates would be awarded to those passing, and it is believed that these certificates would soon come to carry such prestige that they would be accepted within the profession and employers as proof of qualification of the holders of the certificates.

The plan would establish a defined profession of chemistry better than licensing, is the belief of its advocates. It would prevent unqualified persons from becoming chemists; it would be voluntary and so in the American tradition of freedom; it would have direct control over specialties within the profession; a "grandfather" clause would be unnecessary; requirements would be uniform over the whole country; and it would automatically raise the standards of instruction in chemistry in colleges and universities.

Still another point in favor of the certification plan is that a scheme would be evolved for the evaluation of schools based on the quality of product rather than on available facilities, floor space, and teaching personnel.

The chief objection to the certification plan is that it would have no standing at law, whereas under state licensing, there would be legal recognition. The national board could not require those whose work affects public health to prove their competence: State boards can. These points have been advanced by Luaces, who suggests that the plan might be used effectively in conjunction with state licensing.

A study of the controversy on licensing leads to the conclusion that there is unrest among chemists actuated by desire to achieve a more sound economic status and to promote the profession of chemistry.

Survey of the Boron Content of Kansas-Grown Alfalfa[1,2,3,4]

F. M. SMITH, W. G. SCHRENK, and H. H. KING
Kansas Agricultural Experiment Station, Manhattan

Introduction

Records indicate that as early as 1857 boron was known to be an essential element for the growth of certain plants. Since that time the interest in this minor element as a nutrient growth factor of major importance has greatly expanded, as is shown by over 800 listed publications on the subject. The majority of these papers have been published in the past 10 years. They show that the problem of boron deficiency is rather widespread, 31 states in the United States and six provinces in Canada have reported boron deficiencies in over 40 crops.[9] The areas known to be deficient in this country include all the states east of the Mississippi river and those in the Pacific northwest. The middle states and the southwest, however, have apparently been considered to be adequately supplied with the boron necessary for normal plant growth. Although there has been much survey work done in the generally accepted deficient areas in this country, few data have been obtained in Kansas or the states surrounding it. Because of this existing situation, it was felt desirable to make a survey of the boron content of the important crops grown in this state.

Among the crops known to be harmed by a deficiency of boron, alfalfa is one of the most important. This crop apparently requires more boron than many others, and consequently boron deficiency symptoms in any given area are more likely to appear in alfalfa first. In the past few years alfalfa has become of greater economic importance to Kansas because of the relatively greater quantities being grown in the state. Its value as an excellent and cheap source of protein and vitamins for livestock and poultry is well known. With the expanding dehydration of the crop, alfalfa assumes an even more significant place in the Kansas economy and consequently is a factor in the industrial development of the state. This makes it even more important that Kansas maintain its position as a producer of

Transactions Kansas Academy of Science, Vol. 50, Nos. 3 and 4, 1947.

[1]Contribution No. 336 Dept. of Chemistry.

[2]This work has been supported in part by the Kansas Industrial Development Commission.

[3]Presented at the Fifteenth Midwest Regional Meeting of the American Chemical Society, Kansas City, Mo., June 23-25, 1947.

[4]Portion of a thesis presented as partial fulfillment of the requirements for the degree Master of Science at Kansas State College.

high quality alfalfa, and indicates why it was felt advisable to make alfalfa the object of the first study in connection with the boron content of Kansas crops. The following paper presents the results of this preliminary survey and also indicates the effects of various fertilizer treatments on the boron content of alfalfa grown in several localities in the state.

Method of Survey

One of the most important problems in connection with this type of a survey is the availability of a simple method of analysis of adequate precision. Since boron in plant material is present in micro amounts, the main problem concerning an analysis of this type is to have a method that will be sensitive enough to detect the small amount present and also distinguish between small changes in the concentration of the material in the plant. Two methods were immediately suggested, colorimetric and spectrographic. Berger and Truog[1] have used a procedure in which a color is developed for boron by the use of quinalizarin as the color reagent. This method is apparently accurate; however, because of the need of fuming sulfuric acid and the narrow range of acid concentration in which the reagent is sensitive, it is inconvenient. Naftel[7] reported on a method making use of curcumin or turmeric as a color reagent, but this has been shown to be not too sensitive. McHargue et al.[3] worked out a procedure whereby the boron present in plant material is converted to methyl borate, distilled off, and the boron in the distillate determined by spectrographic methods. They also reported the determination of boron directly in the plant ash but without the added controls of spectroscopic buffer and internal standard. Because of these complications this laboratory developed a simple spectrographic method of good precision that requires a minimum of preliminary work. The method will be published at a later date. This procedure gives results that are in good agreement with those obtained by the use of the quinalizarin reagent. All data reported in this paper were obtained by means of the new procedure.

The samples used for the survey were obtained from several localities within the state. These areas were chosen in such a manner as to represent several of the different soil types found in Kansas. All samples were secured at approximately the same stage of growth, that of about one-tenth bloom. This method of sampling would tend to eliminate differences due to variations in boron content caused by collecting samples of different physiological stages of growth. Fields were sampled by obtaining small amounts of

alfalfa from several places within the field and then dividing the sample in the usual manner.

A series of samples of alfalfa being grown on fertilizer plots in three different places in the state was also obtained. These were secured from plots near Thayer, Coffeyville and Columbus in order to show the effects of different soil treatments on the boron content of the plant material.

Discussion of Results

An outline map of Kansas is shown in Figure 1, including the locations from which samples were secured. The general classification of the soils in these areas, as well as in the entire state, can be readily obtained by reference to a map of Kansas prepared by the

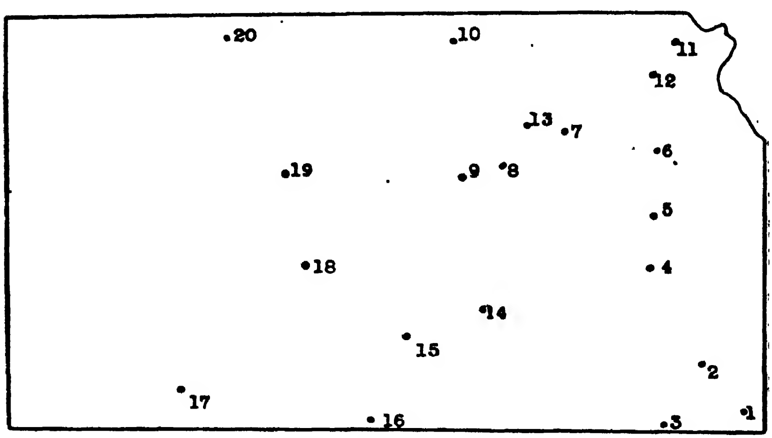


FIG. 1.—Outline map of Kansas showing plots where alfalfa was taken.

1. Columbus	5. Lyndon	9. Salina	13. Wakefield	17. Meade
2. Thayer	6. Topeka	10. Belleville	14. Sedgwick	18. Larned
3. Coffeyville	7. Manhattan	11. Hiawatha	15. Kingman	19. Hays
4. Burlington	8. Abilene	12. Netawaka	16. Kiowa	20. Norton

Soil Conservation Service entitled "Natural Resource Areas of Kansas" by C. L. Fly, soil scientist of Region Five.

The data in Table I represent average analyses of alfalfa grown on untreated plots in the locations given. In general, the southeastern locations produced an alfalfa lower in boron content than did those farther west. Also, it may be seen that the total mineral content is lower in these areas, as evidenced by the lower ash content of the crop. This result may be expected, however, on the basis of rainfall data and the length of time the land has been farmed. These factors would tend to reduce the readily available nutrients

in these areas and could account for such differences. Rainfall in the Columbus area has averaged 41.8 inches annually according to records of the weather bureau, while near Salina the average has been 27.3 inches. This decreases correspondingly farther west. The general soil type within these areas may also be responsible for some of the differences observed.

Table I.—Boron Content of Alfalfa Taken from Untreated Plots in Kansas.

Locality	*Per Cent Ash*	*Boron in p.p.m.*
Columbus	7.10	20.9
Thayer	7.88	33.0
Burlington	7.9	18.9
Lyndon	9.6	41.7
Topeka	7.95	30.1
Manhattan	11.5	32.0
Wakefield	12.9	58.4
Abilene	11.2	28.4
Salina	10.9	43.0
Belleville	9.2	40.9
Hiawatha	9.4	24.0
Netawaka	8.8	38.0
Sedgwick	10.8	37.8
Kiowa	9.1	46.4
Kingman	10.6	48.7
Norton	11.9	38.5
Hays	12.3	56.2
Larned	11.4	45.7
Meade	12.3	50.9

Figures are reported on a dry weight basis.

The results obtained and presented in this table, however, indicate that if the results obtained by Midgley and Dunklee[6] are valid in this area a serious deficiency of boron does not occur, Midgley and Dunklee[6] indicate that in the areas studied by them in eastern United States, alfalfa containing less than 15 ppm of boron will show a favorable response to the application of boron.

The data presented in Table II indicate the effect of different fertilizer treatments on the quantity of boron found in the plant material. It is evident that the addition of certain fertilizer materials reduces the concentration of boron in the alfalfa. This has been explained by some authors [2,4,5,8] as being due to the fixation of boron by the added calcium in the soil, but it might also be caused by the fact that the plant has grown so fast that the mechanism for taking the boron out of the soil has failed to keep up with plant growth. It is also possible, of course, that there is not enough available boron in the soil to allow the plant to take up its full quota of the element due to increased plant growth. Of interest is the fact that the addition of the fertilizers listed in Table II did not significantly increase the concentration of the mineral constituents in the plant, as indicated by the ash content.

Table II.—Boron Content in Alfalfa Taken from Treated Plots at Thayer and Columbus.

Treatment*	Thayer Amount					Thayer Analysis		Columbus Amount					Columbus Analysis	
	L	M	S	R	K	B p.p.m.	Ash %	L	M	S	R	K	B p.p.m.	Ash %
	Ton	*Ton*	*Lb.*	*Ton*	*Lb.*			*Ton*	*Ton*	*Lb.*	*Ton*	*Lb.*		
None						33.0	7.77						20.0	7.35
M		8				33.8	7.51							
L	2					30.6	8.05	1½					19.3	7.82
L. M.	[illegible]	[illegible]				30.4	7.37	1½	8				15.8	8.08
L. M. S.	2	8	150			21.1	7.52	1½	8	120			12.9	7.62
								1½	8	120			17.4	7.13
L. M. R.	2	8		½		20.1	7.32							
L. S.	2		150			21.3	7.36	1½		120			13.2	6.78
						21.3	7.19	1½		120			10.5	6.70
								1½		120			12.0	6.41
								1½		120			12.5	6.50
L. R.	2							1½			½		14.5	7.14
L, 2xS Appl. Bien.	2		300			22.2	7.38							
L. S. K.	2		150		20	25.6	7.35	1½		120		16	14.4	7.15

*M is manure; L is ground limestone; S is 20% superphosphate; R is ground rock phosphate and K is muriate of potash (50%). The figures relate to quantities per acre and are given in pounds and tons.

2xS appl. Bien. means a double application of superphosphate 20% applied biennially.

An examination of the data in Table II on the samples from Columbus indicates that the addition of limestone alone lowers the boron content of the alfalfa somewhat. This has been noted by other workers, as previously mentioned. Limestone used in conjunction with manure caused still another decrease in boron content. Likewise, when superphosphate is added with these two, the boron content is further decreased in one case and increased in the other. When rock phosphate was used with lime, an increase of the boron content was noted over the results obtained when superphosphate was used in place of the rock phosphate with lime. This might be due to increased fixation of boron by the super-phosphate or by the possibility that the rock phosphate carried some boron as an impurity. When potash was used in conjunction with limestone and superphosphate, the boron content was slightly higher than without potash and almost the same as the limestone and rock phosphate treatment. It may be noted that the concentration of boron dropped below the minimum level, suggested by Midgley and Dunklee[6] at Columbus, in all plots where superphosphate was one of the constituents of the fertilizer treatment and came very close to this level in several other instances.

The fertilizer treatments at Thayer show about the same effect as those at Columbus, the primary difference being the slightly higher level of boron in all samples. Manure alone allowed the boron content to remain practically unchanged, but the addition of ground limestone decreased the boron content by about the same percentage as it did at Columbus. The further addition of superphosphate

caused the same magnitude of decrease in boron as that which occurred at Columbus. The addition of potash produced the same type of effect as in the other case. The only Thayer sample from land to which rock phosphate was applied did not show an increase in boron content, nor did a double application of superphosphate materially change the boron content of the alfalfa. In all cases it can be seen that the boron content of the alfalfa under the various treatments at Thayer remained above the maximum suggested previously.[6]

Table III presents data taken from a series of lime and phosphate fertilized plots at Coffeyville. As is true with other cases, the addition of lime decreased the boron content of the plant. The decrease is somewhat irregular; but, in general, an increase in the amount of lime decreased the concentration of boron in the plant. The boron consistently remained above the minimum level recommended in other work.

Table III.—Effect of Adding Lime and Phosphate to Alfalfa Plots. Alfalfa Samples from Coffeyville.

Treatment	*Ash % dry wgt.*	*Boron p.p.m.*
No lime, 100 lbs. 18% Superphosphate	9.32	37.6
2 ton lime, 100 lbs. 18% Superphosphate	9.23	28.2
3 ton lime, 100 lbs. 18% Superphosphate	9.55	34.7
4 ton lime, 100 lbs. 18% Superphosphate	9.40	31.0
5 ton lime, 100 lbs. 18% Superphosphate	9.05	22.1

In order to show the effect of the state of growth on the boron content of the plant at Manhattan, a sample was taken every seven days from the time the alfalfa first showed spring growth until the time of cutting. The data obtained, which is presented in table IV, indicated that apparently the boron content remains relatively constant during growth up until the time of cutting. As the plant gets older the total mineral content decreases although the boron does not seem to decrease in the same ratio.

Table IV.—Boron Content of Manhattan Grown Alfalfa at Seven Day Intervals Up to Time of Cutting.

Time	*Height*	*Ash*	*Boron p.p.m.*
7 days	5 inches	10.6%	34.9
14	10	11.4	32.5
21	14	11.0	38.5
28	17	11.3	34.2
35	21	10.5	32.8
42	24	9.7	34.6
49	27	8.75	27.1

All analyses reported on dry weight basis.

Conclusions

A series of alfalfa samples of approximately the same physiological age secured from various locations in Kansas indicates

that most of the state now has an adequate supply of boron for the production of good quality alfalfa. The boron content is higher in the alfalfa grown in the central areas.

Alfalfa from the extreme southeastern area is lowest in boron content. When the crop is fertilized in this area, the boron content drops to a level which suggests that the addition of boron with other fertilizers should be investigated.

Acknowledgments

The authors wish to thank the Department of Agronomy of Kansas State College and various men in the field who helped collect some of the samples. Thanks are also due Mr. C. O. Grandfield and Mr. Harold Hackerott of the United States Department of Agriculture for help in securing the samples.

Literature Cited

(1) Berger, K. C. and Truog, E. Boron Tests and Determination for Soils and Plants. Soil Sci. 57: 25-36 (1944).
(2) Eaton, F. M. and Wilcox, L. V. The Behavior of Boron in Soils. U.S.D.A. Tech. Bul. 696, pp. 57 (1939).
(3) McHargue, J. S., Offutt, E. B. and Hodgkiss, W. S. Spectrographic Methods for the Determination of Boron in Plant and Animal Materials. Proc. Soil Sci. Soc. Amer. 4: 308-09 (1939).
(4) Midgley, A. R. and Dunklee, D. E. The Cause and Nature of Overliming Injury. Vermont Agr. Expt. Sta. Bul. 460 (June, 1940).
(5) Midgley, A. R. and Dunklee, D. E. The Effect of Lime on the Fixation of Borates in Soils. Proc. Soil Sci. Soc. Amer. 4: 302-07 (1939).
(6) Midgley, A. R. and Dunklee, D. E. Need and Use of Boron for Alfalfa. Vermont Agr. Expt. Sta. Bul. 501 (June, 1943).
(7) Naftel, J. A. Colorimetric Microdetermination of Boron. Ind. and Eng. Chem. Ana. Ed. 11:407-09 (1939).
(8) Naftel, J. A. Soil Liming Investigations: V. The Relation of Boron Deficiency to Overliming Injury. Jour. Amer. Soc. Agron. 29:9 (1937).
(9) Pacific Coast Borax Co. Boron in Agriculture. Revised edition. 61 pp. (1944).

The Stability of Soil Structure Against Falling Water Drops Containing Different Dissolved Materials[1]

T. M. McCALLA[2]

Moisture is added to the soil by rainfall, principally, and by irrigation in limited areas. Water added by rainfall may be as free of impurities as distilled water; more often it may contain some dissolved material such at nitrous or nitric acid fixed by electrical discharge in the atmosphere. Sometimes it contains ammonia and sulfuric or other acids carried into the air by smoke from nearby industrial areas.(1) Irrigation water nearly always contains numerous dissolved salts with ions of sodium, calcium, iron, and magnesium.

Distilled water or water containing dissolved substances may be used in various ways for determining soil structure stability. Dissolved constituents in the water may influence the breakdown of soil structure as the water drops strike it. In addition, the effect of these dissolved constituents on structure may influence the method of applying certain substances for soil stabilization.

The purpose of this investigation was to determine soil structure stability against falling water drops containing different dissolved materials.

Experimental

Various chemical materials were dissolved in distilled water to obtain concentrations ranging from 10 to 10,000 p.p.m. Soil lumps of approximately 0.15 gram were screened from Peorian loess[3] and Marshall silty clay loam.[4] The stability of lumps of Peorian loess and Marshall surface soil against falling drops containing different dissolved substances was determined by the water-drop technique.(2) Results represent the mean of 40 determinations.

Results

Acids.—Acids may be formed from sulfur dioxide or other gases present in the air in areas adjacent to certain industries that

Transactions Kansas Academy of Science, Vol. 50, Nos. 3 and 4, 1947.

[1]Contribution by the Soil Conservation Service, Division of Research, U. S. Department of Agriculture, and the Department of Agronomy, Nebraska Agricultural Experiment Station, Lincoln, Nebraska, cooperating. Published with the approval of the Director as Paper No. 422, Journal Series, Nebraska Agricultural Experiment Station.

[2]Bacteriologist, Soil Conservation Service, Research.

[3]The Peorian loess was obtained near Plattsmouth, Nebraska, at a depth of 15-20 feet. The parent material contains 0.2% oxidizable material by the chromic acid method and has a low structure stability.

[4]Samples of the Marshall silty clay loam were obtained from the Agronomy Farm at Lincoln, Nebr. This soil contains about 4% organic matter and has a structure stability against falling water drops approximately double that of the Peorian loess.

burn coal with a high sulfur content. During electrical storms small quantities of nitrous or nitric acid may be fixed from gaseous nitrogen. Organic and inorganic acids may be present in industrial waste poured into streams. They may be left as a product of decomposition in soils. Since some acids may be present in rain or irrigation water, both inorganic and organic acids were dissolved in distilled water in concentrations ranging from 10 to 10,000 p.p.m. The results of dropping these highly diluted acids on lumps of Peorian loess and Marshall surface soil are shown in Table 1.

Some of these solutions were slightly less effective than others in destroying the structure. In most instances there was no effect on soil structure.

Bases.—Coal smoke may contain ammonia gas. This may react with water to form ammonium hydroxide, which may be carried in small quantities by rain water. This compound may have an effect on soil structure stability. In order to determine the influence of small quantities of dissolved ammonia on soil structure stability, ammonium hydroxide was mixed with distilled water in concentrations of 10, 100, 1,000, and 10,000 p.p.m. Sodium hydroxide was added in similar concentrations and used as a comparison. The results of the drop test with these solutions are shown in Table 2.

No significant change in stability was produced by the ammonia or sodium hydroxide dissolved in water dropped on soil lumps. These results indicate that raindrops containing small quantities of dissolved bases would not break down soil structure any quicker than would raindrops devoid of dissolved materials.

Table 1.—The influence of some acids dissolved in water drops on soil structure stability.

Dissolved acids	P.p.m.				
	0	10	100	1,000	10,000
	Drops per 0.1 gm. of soil				
	PEORIAN LOESS				
Nitric	5.2	5.5	6.0	5.7	5.9
Hydrochloric	5.2	6.6	5.6	5.4	6.6
Sulfuric	5.2	6.3	6.6	5.7	5.4
Acetic	5.2	6.5	5.4	5.4	6.7
Boric	5.2	5.2	6.4	6.2	5.3
Citric	5.2	5.4	5.7	5.4	6.5
Arsenic	5.2	5.9	6.0	6.4	5.8
	MARSHALL SURFACE SOIL				
Nitric	11.8	10.3	11.1	12.6	10.9
Hydrochloric	11.8	12.5	13.9	11.6	12.1
Sulfuric	11.8	12.4	12.9	12.5	10.0
Acetic	11.8	11.0	12.1	12.3	11.6
Boric	11.8	10.3	11.0	10.4	13.7
Citric	11.8	13.6	13.7	12.5	11.7

Salts.—Irrigation water frequently contains varying quantities of different salts, particularly of sodium, calcium, and magnesium. It is also possible that ammonia neutralized by a volatile acid in the

atmosphere would form a sulfate or some other salt that might be present in rain water.

Table 2.—The influence of bases dissolved in water drops on soil structure stability.

Dissolved material	P.p.m.				
	0	10	100	1,000	10,000
	Drops per 0.1 gm. of soil				
	PEORIAN LOESS				
NaOH	5.2	6.7	5.0	6.9	5.5
NH_4OH	5.2	5.7	5.4	5.8	5.6
	MARSHALL SURFACE SOIL				
NaOH	11.8	13.9	10.0	13.3	14.4
NH_4OH	11.8	9.9	11.0	10.2	11.3

To determine the influence of salts dissolved in water drops, different solutions were made containing various salts in concentrations ranging up to 10,000 p.p.m. The results obtained by waterdrop technique with these solutions on Peorian loess and Marshall surface soil are shown in Table 3.

The salts of sodium, ammonium, magnesium, iron, or calcium gave the same results as distilled water with lumps of Peorian loess or Marshall surface soil. This indicates that results obtained by the water-drop technique for soil structure stability with distilled water would be similar to those obtained with rain water containing the same salts in concentrations up to 10,000 p.p.m.

Organic Substances.—In some instances organic substances may be present in the atmosphere and be brought down in rain water. In other instances it might be desirable to spray certain organic substances on the soil. The initial application of organic substances in water might either stabilize or cause a deterioration of the soil structure. To determine the effect of organic matter, humus obtained by allowing straw to decompose was added to Peorian loess and Marshall surface soil. In addition, Vinsol,[5] 10 per cent solution of dodecyl dimethylamine sulfate, 20 per cent solution of dodecyl dimethyl benzyl ammonium chloride and 2, 4-D were made up in concentrations up to 10,000 p.p.m. The results are shown in Table 4.

The 2,4-D solution gave the same results as distilled water. A longer time was required to break down the soil structure with water drops containing organic matter and Vinsol. Previous results[(2)] showed that decaying organic matter, added to the Peorian loess and then dried before testing increased stability against falling water drops. This may be the result of the organic substance changing the surface tension or wetting ability of the water. The more con-

[5]Vinsol, a synthetic organic resin, was obtained through the courtesy of Hercules Powder Company, Wilmington, Delaware. The dodecyl dimethylamine sulfate and dodecyl dimethyl benzyl—ammonium chloride are products of the Onyx Oil and Chemical Co., Jersey City, New Jersey. These are surface-active substances.

Table 3.—The influence of some salts dissolved in water drops on soil structure stability.

Dissolved material	P.p.m. 0	10	100	1,000	10,000
	Drops per 0.1 gm. of soil				
	PEORIAN LOESS				
NaCL	5.2	5.3	4.9	5.4	4.9
$NaNO_3$	5.2	5.2	5.9	5.0	5.3
Na_2CO_3	5.2	5.1	5.6	6.3	5.2
$FeSO_4$	5.2	5.2	5.9	5.6	5.7
NH_4NO_3	5.2	5.3	5.6	6.0	5.4
$MgSO_4$	5.2	5.1	5.1	5.5	5.5
$CaCO_3$	5.2	5.5	5.4	5.2	5.8
	MARSHALL SURFACE SOIL				
NaCL	11.8	12.1	11.9	11.1	10.0
$NaNO_3$	11.8	10.5	10.9	10.1	10.7
Na_2CO_3	11.8	9.9	11.1	10.5	10.1
NH_4NO_3	11.8	12.1	11.2	11.3	12.4
$MgSO_4$	11.8	10.3	10.4	11.3	9.6
$CaCO_3$	11.8	10.9	10.8	10.8	10.7
Sulfur	11.8	11.6	10.2	10.9	12.2

centrated the solution, the more effective were the treatments in stabilizing soil structure.

More drops of the dodecyl dimethylamine sulfate and dodecyl dimethyl benzyl ammonium chloride solutions than of distilled water were required to break down the structure of the Peorian loess and Marshall surface soil.

Sprays.—Bordeaux mixture, ferric-dimethyl dithio carbonate[6] and wettable sulfur were added to distilled water in concentrations up to 10,000 p.p.m. The more concentrated suspensions were filtered through a layer of cheesecloth and the filtrate used for applying to the lumps. The results are given in Table 5.

These spray materials gave essentially the same results as distilled water on Peorian loess or Marshall surface soil.

Insecticides.—Some insecticides,[7] 5 per cent 1068 in pyrophyllite, 25 per cent emulsion of 1068, pyrophyllite (carrier for insecti-

Table 4.—The influence of some organic materials dissolved in water drops on soil structure stability.

Material dissolved	P.p.m. 0	10	100	1,000	10,000
	Drops per 0.1 gm. of soil				
	PEORIAN LOESS				
2, 4-D	5.2	5.7	5.4	5.9	5.2
Organic matter	5.2	6.3	6.1	6.9	7.9
Vinsol	5.2	5.2	5.9	7.1	16.1
Dodecyl dimethylamine sulfate 10%	5.2	5.9	5.7	9.0	9.9
Dodecyl dimethyl benzyl ammonium chloride 20%	5.2	5.5	6.2	7.7	13.1
	MARSHALL SURFACE SOIL				
2, 4-D	11.8	10.6	11.7	11.7	12.9
Organic matter	11.8	11.2	16.6	18.1	28.6
Vinsol	11.8	12.6	17.7	19.2	37.5
Dodecyl dimethylamine sulfate 10%	11.8	12.1	11.3	12.8	15.5
Dodecyl dimethyl benzyl ammonium chloride 20%	11.8	10.2	11.4	18.4	27.2

[6]The spray materials were obtained from R. H. Moore, Department of Horticulture, University of Nebraska.

[7]The insecticides were obtained from E. Hixon, Chairman, Department of Entomology, University of Nebraska.

Table 5.—Influence of some spray materials on soil structure stability against falling water drops.

Dissolved material	P.p.m. 0	10	100	1,000	10,000
	Drops per 0.1 gm. of soil				
	PEORIAN LOESS				
Ferric-dimethyl dithio-carbonate	4.5	4.7	4.8	5.7	6.8
Bordeaux mixture	4.5	5.1	5.8	5.1	5.8
Wettable sulfur	4.5	4.6	4.7	5.2	5.6
	MARSHALL SURFACE SOIL				
Ferric-dimethyl dithio-carbonate	10.8	10.6	9.9	11.0	11.3
Bordeaux mixture	10.8	10.3	10.3	9.4	10.8
Wettable sulfur	10.8	9.3	9.9	10.9	10.6

cide), 50 per cent wettable benzene hexachloride, and DDT (5 per cent in pyrophyllite base) were made up in concentrations up to 10,000 p.p.m. These solutions were then dropped on lumps of Peorian loess and Marshall surface soil. Mixtures carrying pyrophyllite in the 1,000 and 10,000 p.p.m. concentrations were filtered through a layer of cheesecloth before using. Results are shown i Table 6.

The 25 per cent emulsion of 1068 and 50 per cent wettable benzene hexachloride increased the stability of Peorian loess. The 25 per cent emulsion of 1068 increased the stability of the Marshall surface soil in the higher concentrations. Other substances did not change the stability of Peorian loess or Marshall surface soil.

These results indicate that more drops of some insecticides-solution than of distilled water falling from a spray might be required to break down soil structure. Others may have the same effect as distilled water.

Discussion

Rain water, usually about as pure as distilled water, at times may be contaminated with certain organic and inorganic impurities. The results obtained in this investigation indicate that in measuring the effect of different treatments on soil structure stability against

Table 6.—Influence of some insecticides on soil structure stability against falling water drops.

Dissolved materials	P.p.m. 0	10	100	1,000	10,000
	Drops per 0.1 gm. of soil				
	PEORIAN LOESS				
5% 1068 in Pyrophyllite	4.5	4.9	5.0	5.2	5.3
25% emulsion of 1068	4.5	4.7	5.2	5.5	7.1
50% wettable benzene hexachloride	4.5	4.7	4.4	5.0	6.8
DDT, 5% in pyrophyllite	4.5	4.4	4.4	5.1	5.0
Pyrophyllite	4.5	4.6	4.5	4.4	4.0
	MARSHALL SURFACE SOIL				
5% 1068 in pyrophyllite	10.8	10.3	10.8	10.2	9.7
25% emulsion of 1068	10.8	11.2	10.7	12.1	16.8
50% wettable benzene hexachloride	10.8	10.4	9.1	9.3	10.4
DDT, 5% in pyrophyllite	10.8	11.5	11.4	11.1	9.6
Pyrophyllite	10.8	10.8	10.7	9.8	10.5

water drops, small quantities of dissolved acids, bases or salts, even in concentrations up to 10,000 p.p.m., in the water would not change the results over those obtained with distilled water. Also, it appears from these results that rain or possibly irrigation water, containing small quantities of dissolved inorganic materials would not break down soil structure any quicker than distilled water.

If a spray contained certain compounds such as dodecyl dimethylamine sulfate, dodecyl dimethyl benzyl ammonium chloride, Vinsol, humus from decaying straw, more drops of these solutions than of distilled water falling against the soil would be required to break down the structure. More drops of some insecticide solutions than of distilled water would be required to break down soil structure. A different effect might be found if these substances were added to the soil and then the stability of the soil tested against falling water drops.

Summary

A number of acids, bases, salts, and organic substances were dissolved in distilled water. The solutions were applied to the lumps of Peorian loess and Marshall surface soil by the water-drop technique.

Under these conditions of testing, none of the inorganic substances produced a significant change in stability from that obtained with distilled water. More drops of the Vinsol, humus or decaying straw, dodecyl dimethylamine sulfate, and dodecyl dimethyl benzyl ammonium chloride solutions were required than drops of the distilled water to break down the soil structure.

Water containing acids, bases, and salts in concentrations not exceeding 10,000 p.p.m. of solute to solution gave the same results as distilled water with the water-drop method of determining soil structure stability. The acids (hydrochloric, sulfuric, acetic, boric, citric) in concentrations up to 10,000 p.p.m. did not change the stability of the soil structure against falling water drops. The salts (sodium chloride, sodium nitrate, sodium carbonate, ammonium nitrate, magnesium sulfate) gave similar results. Likewise, the ammonium or sodium hydroxide solutions had the same effect on the soil structure as distilled water.

The DDT and 2, 4-D had the same effect on the stability of the soil as distilled water as applied by the water-drop technique. Two of the insecticides in the higher concentrations, 25 per cent emulsion of 1068 and 50 per cent wettable benzene hexachloride, required

more drops of the solution than of distilled water to break down the soil structure.

References

(1) Collison, R. C. and Mensching, J. E. 1932. Lysimeter investigations: II. Composition of rainwater at Geneva, N. Y. for a 10-year period. Tech. Bul. 193: 1-19.

(2) McCalla, T. M. 1944. Water-drop method of determining stability of soil structure. Soil Sci., 58: 117-123.

(3) McCalla, T. M. 1945. Influence of microorganisms and some organic substances on soil structure. Soil Sci., 59: 287-297.

Application of the Electronic Theory to Some Simple Organic Reactions. III.[1]

CALVIN A. VANDER WERF
University of Kansas, Lawrence

Application of the electronic theory to a study of many of the important base-catalyzed condensation reactions widely used in synthetic organic chemistry makes possible a simple classification and correlation of these reactions based on mechanism. Considered, for example, in the light of the seventy-five year controversy over the mechanism of such a familiar reaction as the Claisen condensation, the new electronic interpretations of these reactions appear remarkably simple and revealing. The present paper consists of a discussion, in terms of modern electronic theory, of the mechanisms of the following base-catalyzed condensation reactions: alkylation, the Claisen condensation, the Dieckmann reaction, the aldol condensation, and the Thorpe, Knoevenagel, Perkin, Kato, and Michael reactions. All of these important condensations will be classified and correlated on the basis of mechanism.

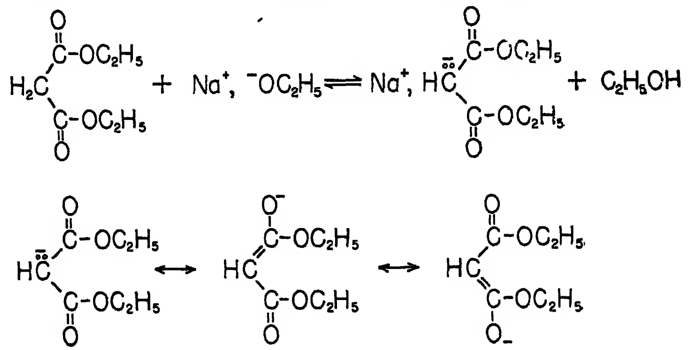
Stated in the broadest possible terms, the first step in each of the above named type reactions is thought to be the removal as a proton, by the basic catalyst, of a somewhat acidic hydrogen attached to a carbon atom. In every case, the carbanion formed by the removal of the proton is stabilized through resonance. In most, but not all, instances the acidic hydrogen attached to the carbon atom owes its acidity to the presence, at the α-position, of an electron withdrawing group, usually a highly electronegative atom joined to the α-carbon through a multiple bond. All of these type reactions may be grouped into two broad classes, depending upon the nature of the reaction of the carbanion, formed in the first step, with the condensing molecule. The carbanion may attack the positively charged carbon atom of the activated condensing molecule displacing a negatively charged monovalent atom or group attached to the carbon. This type of reaction which may be summarized by the general equation $Y^- + -\overset{|}{\underset{|}{C}}-X \rightarrow -\overset{|}{\underset{|}{C}}-Y + X^-$, in which Y^- represents the carbanion and X the negatively charged monovalent atom or group attached to the positive carbon in the condensing molecule, may be classified as a displacement type condensation reaction.

Displacement Type Condensation Reactions

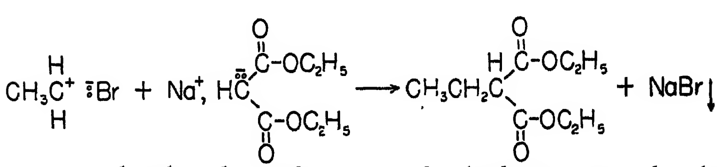
Of the general base-catalyzed reactions listed above, alkylation,

the Claisen condensation, and the Dieckmann reaction are of the displacement type. In the typical base-catalyzed alkylation reaction, the reactants are a 1, 3 – dicarbonyl compound, such as malonic and acetoacetic esters, and an alkyl halide. Sodium ethoxide is the usual basic catalyst. The reaction is initiated by the base, which removes an acid hydrogen, as a proton, from the dicarbonyl compound, thus converting the compound into a carbanion which is stabilized through resonance. The carbanion then attaches itself to the positive halogen-bearing carbon atom of the alkyl halide molecule, displacing the halide ion. The latter is precipitated in the form of its sodium salt which is insoluble in alcohol, the usual solvent for the reaction. These steps are illustrated below for the alkylation of malonic ester with ethyl bromide in the presence of sodium ethoxide:

(I)



(II)



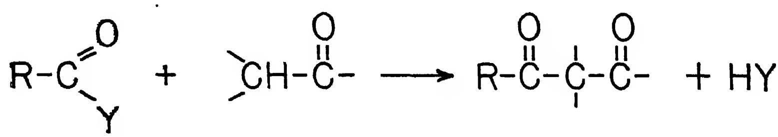
It is noteworthy that the replacement of a hydrogen atom by the less electronegative alkyl group decreases the acidity of the malonic ester. In other words, the monoalkyl derivative is less acidic than the original ester. Consequently, the monoalkyl derivative competes unsuccessfully with malonic ester itself in the donation of a proton to the basic catalyst (Step I), and mono-alkylation is favored, with very little dialkylation occuring.

Compounds of the type of malonic and acetoacetic esters give acylation products when an acid chloride or an acid anhydride is used in place of the alkyl halide. The carbanion formed from the 1,3–dicarbonyl compound displaces the chlorine atom from the acid chloride in the form of the chloride ion and the RCOO– group from

the anhydride in the form of the carboxylate ion. These reactions cannot, of course, be run in alcohol solution.

Many simple ketones, as well as 1,3-diketones and keto-esters, can be alkylated. A stronger base than ethoxide ion, usually the amide or hydride ion added in the form of the sodium salt, is required as catalyst, and solvents, such as alcohols, which are slightly acidic, must be replaced by non-acidic solvents like ether and benzene.

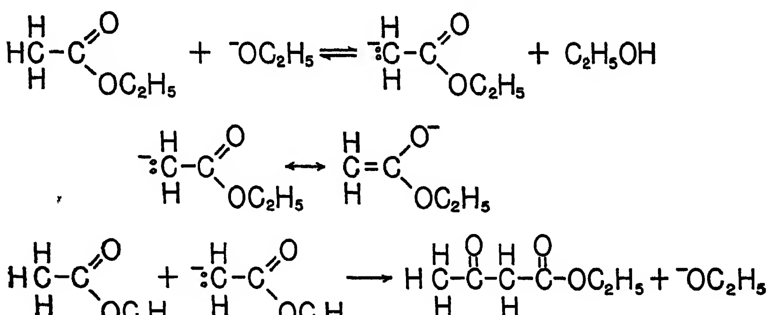
In its broadest sense, the Claisen condensation includes within its scope all base-catalyzed reactions of carboxylic esters, acid anhydrides, and acid chloride with aldehydes, ketones, and esters to form β-keto derivatives. The type reaction may be represented by the following generalized equation:



Ester, Anhydride, or Acid Chloride — Aldehyde, Ketone, or Ester

Sodium ethoxide, sodamide, mesityl magnesium bromide, pyridine, and similar basic catalysts are required to effect reaction.

It is probable that the first step in the Claisen condensation is the removal by the basic catalytic anion of a proton from the α-carbon atom of the aldehyde, ketone, or ester molecule. The carbanion thus formed then attaches itself to the oxygen-containing carbon of the ester, anhydride, or acid chloride molecule with the splitting out of an alkoxide, carboxylate, or chloride ion. The self condensation of ethyl acetate to form ethyl acetoacetate is the most common example of the Claisen condensation. The reaction with sodium ethoxide as the catalyst may be shown as follows:



For many years, it was believed that only esters which contained at least two hydrogen atoms on the α-carbon atom could undergo

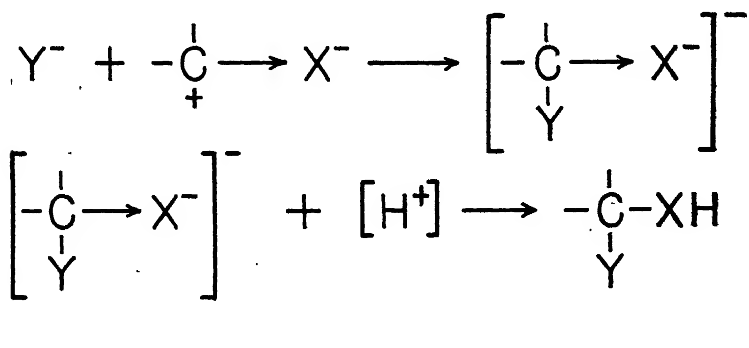
the Claisen condensation. Recently, however, it has been shown that esters with only one hydrogen atom on the α-carbon can show appreciable condensation, but only when a catalytic anion considerably more basic than the ethoxide ion is used. Ethylisobutyrate, for example, which does not undergo condensation when sodium ethoxide is added, readily condenses if mesitylmagnesium bromide or sodium triphenylmethyl is the catalyst. The need for a more basic catalyst is explained by the fact that the replacement of a methyl group for a hydrogen atom on the α-carbon in ethyl propionate brings about a marked decreased in acidity, i.e., ethyl isobutyrate is less acidic than ethyl propionate.

The Dieckmann reaction is simply an intramolecular Claisen condensation. It occurs readily when the functional groups involved are so located in the molecule that five or six membered rings are formed in the intramolecular condensation.

Addition Type Condensation Reactions

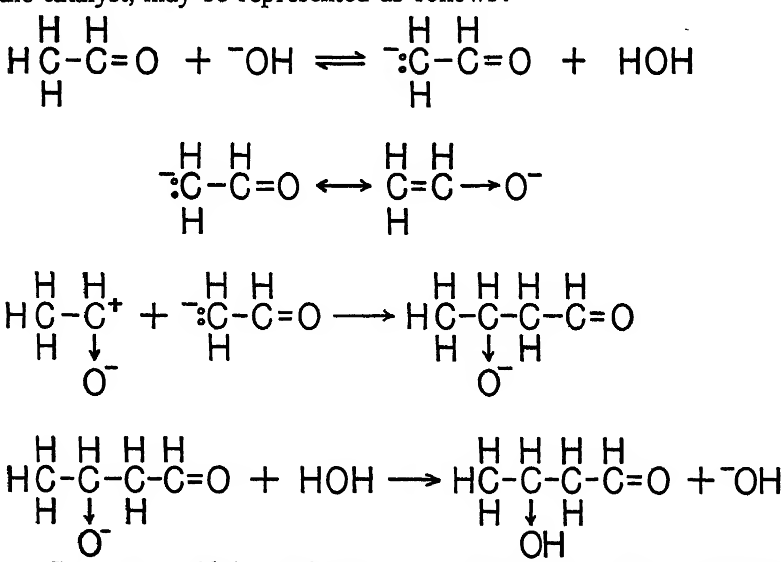
In the second general class of base-catalyzed condensations, the carbanion formed in the initial step of the reaction, just as was the case in the displacement-type reaction, attacks a positive carbon atom in the activated condensing molecule. Here, however, the anion formed by this addition does not split out some negative ion, but rather adds a proton to a negatively charged atom joined to the positively charged carbon atom at which the attack occurred. This negatively charged atom must, of course, be linked to the carbon through a classical double or triple bond. The total reaction is thus equivalent to the addition of a carbanion and a proton across a multiple bond, with the carbanion adding to a positively charged carbon atom and the proton to a negatively charged atom linked to the carbon through a multiple bond.

In the general case, this type of reaction may be shown as follows, where Y^- represents the carbanion formed in the first step of the reaction and X is the negatively charged atom joined by a multiple (in the classical sense) bond, to the positive carbon atom of the activated condensing molecule:



The proton shown in the second step is usually furnished by the solvent or by the conjugate acid of the basic catalyst. This general type of reaction, which includes the aldol condensation, and the Thorpe, Knoevenagel, Perkin, Kato, and Michael reactions, may be described conveniently as an addition type condensation. Certain of these reactions are slightly complicated by the fact that the addition product first formed goes on to lose a molecule of water.

The simple aldol condensation may be used to serve as the prototype for all addition condensation reactions. In the usual aldol condensation, the carbanion formed by the catalytic removal of a proton from the α-carbon atom of a molecule of aldehyde or ketone adds to the carbonyl-carbon atom of a second molecule of aldehyde or ketone. The reaction is consummated by the transfer of the proton from the conjugate acid of the catalyst to the carbonyl oxygen atom of the addendum anion. For the simple case of acetaldehyde, the steps in this mechanism when hydroxide ion is the catalyst, may be represented as follows:



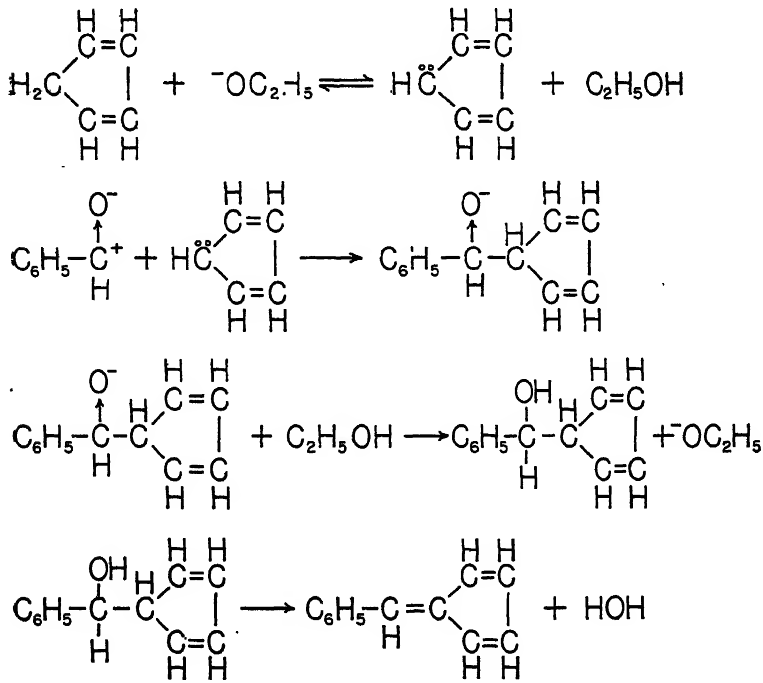
In many aldol condensations, particularly those involving ketones, the aldol or ketol formed loses a molecule of water to form an α, β-unsaturated aldehyde or ketone. In the base-catalyzed condensation of benzaldehyde with acetone, for example, the product is benzalacetone:

$$C_6H_5CHO + CH_3COCH_3 \rightarrow C_6H_5CH{=}CHCOCH_3 + H_2O$$

A wide variety of basic catalysts such as sodium hydroxide, sodium

acetate, sodium cyanide, sodium ethoxide, and aluminum t-butoxide are used as catalysts for aldol condensations.

An interesting variation of the simple aldol condensation is that involving the condensation of acidic hydrocarbons such as cyclopentadiene and its benzologs, indene and fluorene, with aldehydes. The carbanion formed by the removal of a proton from these hydrocarbons is greatly stabilized through resonance. Removal of a proton from cyclopentadiene, for example, produces a resonance hybrid which exhibits five different resonance structures, all equivalent.[2] Such an ion adds to the carbonyl-carbon atom of an aldehyde or ketone in the usual fashion. In the ethoxide ion-catalyzed condensation of cyclopentadiene with benzaldehyde to form phenylfulvene, the steps are as follows:



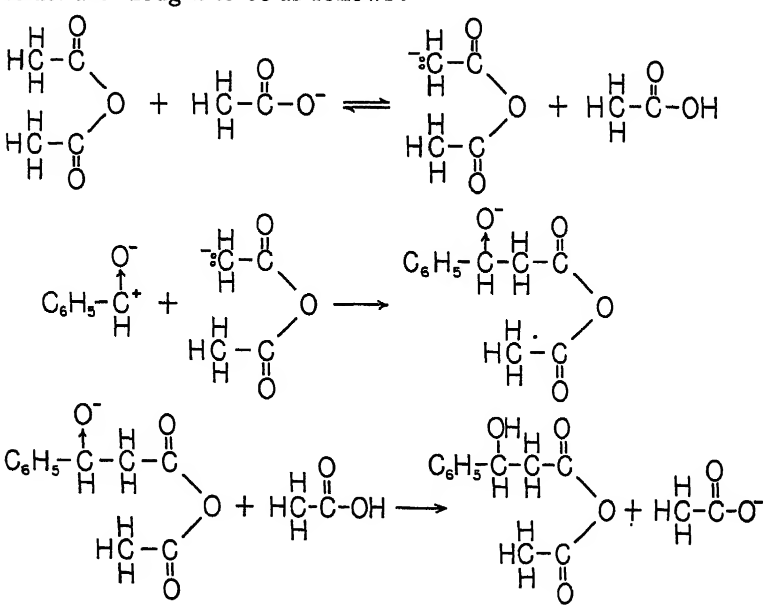
Many nitroalkanes likewise condense with aldehydes in base-catalyzed reactions. The carbanion formed by the loss of a proton from the carbon atom bearing the nitro-group in the nitroalkane adds to the carbonyl-carbon atom of the aldehyde to give an addendum anion which then adds a proton at the carbonyl-oxygen atom. The initial product thus formed is a nitro-alcohol.

The Thorpe reaction is actually a modification of the simple aldol condensation in which the carbanion formed by the loss of a proton from the α-carbon atom of a nitrile molecule adds to the nitrile-carbon atom of a second molecule of nitrile. Sodium ethoxide is the usual catalyst. Benzyl cyanide undergoes the Thorpe reaction to produce α-γ-diphenyl-β-imino-n-propyl nitrile, as represented by the following overall equation:

$$C_6H_5CH_2C \equiv N + C_6H_5CH_2C \equiv N \rightarrow C_6H_5CH_2\overset{NH}{\overset{\|}{C}} - \overset{C_6H_5}{\overset{|}{C}}HC \equiv N$$

In the Knoevenagel reaction, which may be catalyzed by sodium ethoxide, the carbanion which adds to the aldehyde is one formed from such compounds as malonic and acetoacetic esters. The molecule formed by the addition of the carbanion and the proton across the carbonyl double bond then loses water. For the condensation of malonic ester with benzaldehyde, the total reaction is as follows: $C_6H_5CHO + CH_2(COOC_2H_5)_2 \rightarrow C_6H_5CH = C(COOC_2H_5)_2 + H_2O$

It is now generally believed that the Perkin reaction proceeds through the intermediate formation of the carbanion of the anhydride, followed by the attack of this carbanion on the carbonyl-carbon of the aldehyde. The steps in the Perkin condensation of acetic anhydride with benzaldehyde in the presence of the catalyst sodium acetate are thought to be as follows:



The mixed anhydride shown as a product in the last equation loses a molecule of water and is hydrolyzed to form cinnamic and acetic acids.

Kato[3] has observed that acid chlorides of the type RCH_2COCl condense with benzaldehyde by a similar mechanism in the presence of triethylamine to yield substituted cinnamic acids. The general equation is as follows:

$$C_6H_5CHO + RCH_2COCl \rightarrow C_6H_5CHOHCHRCOCl \rightarrow C_6H_5CH{=}CRCOCl + H_2O \rightarrow C_6H_5CH{=}CRCOOH + HCl$$

Perhaps the most interesting of the addition type condensations is the Michael reaction in which a wide variety of slightly acidic compounds such as malonic ester, acetoacetic ester, and certain simple esters, ketones, nitriles, and nitroalkanes condense with $\alpha,$-β-unsaturated carbonyl compounds in the presence of basic catalysts. In this reaction, however, the carbanion and proton add, not across the carbonyl double bond, but rather across the olefinic double bond. The overall reaction for the base-catalyzed condensation of malonic ester with mesityl oxide is as follows:

$$(CH_3)_2\,C = CHCOCH_3 + CH_2(COOC_2H_5)_2 \rightarrow$$
$$(CH_3)_2\,\underset{\displaystyle CH(COOC_2H_5)_2}{\overset{}{C}}\,CH_2CO\,CH_3$$

This type of reaction is particularly interesting because the presence of the strongly electron-withdrawing carbonyl group so increases the cationic character of the olefinic bond at the expense of its anionic character,[4] that the first step in addition to the double bond can be an attack on a cationic carbon atom by an anionic reagent such as a carbanion.

Summary

1. The following common base-catalyzed condensation reactions have been classified and correlated on the basis of mechanism: alkylation, the Claisen condensation, the Dieckmann reaction, the aldol condensation, and the Thorpe, Knoevenagel, Perkin, Kato, and Michael reactions.

2. Base-catalyzed alkylation, the Claisen condensation, and the Diekmann reaction may be grouped together as displacement type condensation reactions, whereas the aldol condensation and the Thorpe, Knoevenagel, Perkin, Kato, and Michael reactions are similar in that they are all addition type condensations.

Literature Cited

(1) Previous paper in this series: VanderWerf, these *Transactions*, 49, 346 (1946).
(2) VanderWerf, Journ. Chem. Ed., 22, 40 (1945).
(3) Kato, Sci. Rep. Tokyo Bunika Daigaku, A2, 257 (1935).
(4) VanderWerf, these *Transactions*, 48, 91 (1945).

Kansas Academy of Science—Report of the Treasurer

April 6, 1946 to March 27, 1947

Receipts

Balance in checking account, April 6, 1946	$ 955.39	
Annual dues for memberships	1,078.00	
Three Life memberships	65.00	
Sale of Transactions	62.35	
Sale of Winter Twigs	7.40	
Reprints	224.97	
Sale of Science and War Reprints	6.75	
State of Kansas	600.00	
Exchange Rights	300.00	
Sale of Percentage Tables	.75	
Refund on Voucher No. 3194 from Capper Engraving Co.	100.67	
AAAS (April 6, 1946 to March 27, 1947)	.00	
Interest on Investments	66.99	
		$3,468.27

Disbursements

Secretary—stamps, help, stationery, etc.		$ 115.88	
Treasurer—stamp and 1946 report		2.42	
Executive Council Members Mileage—Nov. 2, 1946		24.26	
Annual Banquet and lapel badges		8.02	
Junior Academy Awards		18.36	
Dorothea Franzen		65.00	
Spring Programs		39.00	
Sectional Chairmen (Psychology and Zoology)		2.50	
Workman Printing Co. (Letterheads, envelopes, cards)		39.00	
Workman Printing Co. (Folders, over printing cards)		18.00	
Elliott Addressing Co.		9.14	
The Outlook (Clasp envelopes)		32.00	
Managing Editor Expense		95.82	
Transactions of the Kansas Academy of Science:			
Capper Engraving Co., No. 2327	$ 70.49		
Capper Engraving Co., No. 4054	4.46		
Capper Engraving Co., No. 3992	105.06		
Capper Engraving Co., No. 3194	100.67		
Capper Engraving Co., Nos. 3194, 3992, 4054	236.94		
Capper Engraving Co., No. 5896	120.75		
The World Company, No. 21758	482.90		
The World Company, No. 22304	513.25	1,634.52	
		$2,103.92	
Balance in checking account, March 27, 1947		1,364.35	
			$3,468.27

Supplementary Statement

Outstanding checks No. 22, 29, 31, 38		$ 32.34
Accounts Receivable		
Library exchange, Kansas University	$ 200.00	
Reprints	22.75	222.75

Investments

In Endowment Fund	$4,099.98	
In General Fund, interest on endowment fund	378.60	
		$4,478.58

Awards Account

Amount in fund April 6, 1946		$ 215.90
Received during the year:		
Reagan Bond	$ 25.00	
A.A.A.S.	.00	25.00
Total		$ 240.90
Awarded (Spring 1945)	$ 65.00	
Amount paid	65.00	65.00
Balance		$ 175.90

STANDLEE V. DALTON, *Treasurer.*

Index—Volume 50

Original articles are entered under the name of their fields (Archeology, Chemistry, etc.), under the name of the author (given in italics) and under the title, usually abbreviated (and also in italics).

Date of Issue	Date of Issue	Date of Issue
22.1.69		
	27 FEB 2004	

GIPNLK—H-40 I.A.R.I.—29-4- 5—15,000